UTHEP/COM/2019/8398 including clarification about Engineers comment on previous revision.

Upper Tamakoshi Hydroelectric Project (Lot 1 Civil works)
Contract No. UTKHEP/03-2064/65

Method Statement for Barrier Grouting In Headrace Tunnel

中国水电
SINOHYDRO

Prepared by: Ji Xue Jun, Shadananda Gautam
Reviewed by: Sheng Dongfeng
Approved by: Lei Chunhua

UTKHEP, SINO HYDRO CORPORATION LTD.
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LOT 1-CIVIL WORKS

METHOD STATEMENT FOR BARRIER GROUTING IN HEADRACE TUNNEL

ORIGINATOR: SINOHYDRO

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CONTENTS

1. References 1
2.Project Summary 1
2.1 Introduction: 1
2.2 Technical Requirement: 2
3.Construction Layout 4
3.1 Access Road 4
3.2 Air Supply 4
3.3 Water Supply 4
3.4 Power Supply and Lighting 4
3.5 Cement and Other Materials 4
3.6 Grouting Platform 4
3.7 Communication 5
4.Measures and Methodology 5
4.1 Drilling of Holes 6
4.2 Washing of Holes 6
4.3 Water Pressure Test 7
4.4 Grouting of Holes 7
5.Construction Schedule 11
6.Resource Allocation Plan 12
6.1 Manpower 12
6.2 Equipment & Machinery 13
7 Quality Assurance Measures 15
8 Safety Guarantee Measures 15
9 Construction Work Discipline 16
10 Organigram for Each Face of Barrier Grouting 17
11 QA/QC Test 17
11.1 Bleeding Test: 17
11.2 Viscosity (Marsh Cone) Test 18
11.3 Setting Time (Initial and Final) 18
11.4 Density Test by Liquid Hydrometer 19
12 Grouting Over View Report 20
Appendices
Annex A: Equipment
Annex B: Material
Annex C: Format
Annex D: Bio-data
Annex E: Safety Plan
Annex F: Design Drawing for Grouting

List of Figure

Figure 1: Grouting Platform Sectional View 4
Figure 2: Bleeding Test Apparatus According to Widmann 17
Figure 3: Liquid Hydrometer to Measure Density of Grout Liquid 19

List of Table

Table 1: List of Concrete Lining Section in the Headrace Tunnel 1
Table 2: Bill of Quantity 3
Table 3: Mix Proportion of Grout Based on Lugeon Value 9
Table 4: List of Grouting Pressure 10
Table 5: List of Manpower 12
Table 6: List of Construction Equipment & Machinery 13

Introduction

Barrier Grouting in HRT

1. References

Ref. 1. Project contract tender documents, volume 4, section 5.

Ref. 2. The Project construction organization design and work plan.

Ref. 3. Headrace tunnel grouting drawing: UTK-012065-4420 Q-015 Rev.A, UTK-012065-4420 Q-016 Rev.A and UTK-012065-4420-Q060 Rev.A, UTK-012065-4410-Q-060 Rev.B.

2. Project Summary

2.1 Introduction:

Headrace Tunnel will cover a new total length of 8,059.96m where Bhaise Adit will be at chainage of CH2+914.57 with elevation EL1958.8 and Penstock Tunnel will be at chainage of CH7+749.94 with elevation EL1871.86.

Barrier grouting will be done in the transition zones at the start and end of each section of lining. According to the Engineer's letter 4248, the Headrace Tunnel requires concrete lining at the following sections.

Table 1: List of Concrete Lining Section in the Headrace Tunnel

S.N.	Chainage of Lining Section	Length of Section (m)	Remarks
1	Headrace tunnel intake	20	HT1
2	CH3+557~ CH3+830	273	Section D
4	CH4+395~CH4+505	110	Section C
5	CH6+051~CH6+131	80	Section B
6	CH7+220~CH7+989	769	Section A
	Total	1252	

Normally, Barrier grouting will be done before concreting lining work, but in the section of CH0+15.5~CH0+18.5, concrete lining work has been already finished, that's why only this section was approved to do the barrier grouting after concrete lining work. The Method Statement for barrier grouting only for section of CH0+15.5~CH0+18.5 has been approved on October. This Method Statement for barrier grouting is for all remaining sections as the followings.

Bhaise adit plug, CH3+557~CH3+830, CH4+395~CH4+505, CH6+051~CH6+131, CH7+220~CH7+989 and other shear zone linings (if any).

2.2 Technical Requirement:

2.2.1 Drwg. No. UTK-012065-4420-Q-060

Initially, 12m long holes shall be drilled into rock in a radial pattern in two fans: fan 1 & fan 2 as shown on drawing. Each fan shall have eight holes spaced at 45° around the circumference. The holes in fan 2 shall be drilled in staggered position compared to the holes in fan 1. Each hole shall be water pressure tested for leakage (Lugeon) with packer setting 5m inside the rock surface. After testing all holes shall be grouted with packer setting at 5m using cement-based grout type A if permeability is above 3 Lugeon and type B if permeability is less than or equal to 3 Lugeon. For detail of mix proportion and threshold values, see chapter 4.4.4.

After completing grouting of fan 1 and fan 2, and if the permeability tests in any hole have shown water loss above 0.5 Lugeon, additional 12m long holes shall be drilled in between fan 1 and fan 2 at a "split spacing" pattern tested, grouted and retested. This procedure shall be repeated until all new holes show water losses equal or below 0.5 lugeon. Final grouting pressure shall be 30 bars with zero flow for 5 minutes or as decided by the Engineer during the grouting works. After completing deep grouting, the outer 4-4.5m in rock of every hole shall be water pressure tested for leakage with packer setting 0.5-1.0m into rock. After testing, all holes shall be grouted with packer setting 0.5-1.0m into rock with above mentioned threshold value.

If the water pressure test in any hole has shown water loss greater than 0.5 Lugeon, new 5m long holes shall be drilled at both sides of the holes (or according to the Engineer suggestion), then permeability tested and grouted. This procedure shall be repeated as described above until all new holes show permeability less than or equal to 0.5 Lugeon.

Grouting shall start with the invert and end at the crown. Grouting shall be interrupted at any sign of cracking or movement of the invert and to be continued only at the engineer's instruction. Upon completion of grouting, all grouted holes shall be filled up by expanding mortar.

2.2.2 Drwg. No. UTK-012065-4420-Q-015

1) Shallow grouting 5m long holes in rock

Holes shall be drilled in a radial pattern in four grout fans; A, C, E and G each fan consisting of eight holes spaced at 45° around the circumference. Holes in fan C and G shall be drilled in staggered position compared to fan A and E.

Perform water pressure testing with packer setting at 0.5-1.0m depth as directed by the Engineer from rock surface. After testing, the holes shall be grouted with cement-based grout type A if permeability is larger than 3 Lugeon and type B if permeability is less than or equal to 3 Lugeon. Final grouting pressure shall be at 30 bar for minimum 5 minutes or as directed by the Engineer during grouting. For detail of mix proportion and threshold values, see chapter 4.4.4.

If the water pressure test in any grouting hole shows water loss above 0.5 lugeon, new holes shall be drilled at both sides at a "split spacing" pattern in each fan (or as suggested by the Engineer), this procedure shall be repeated until all new holes show

permeability less than or equal to 0.5 Lugeon.

2) Deep grouting 25m long holes

Holes shall be drilled in a radial pattern in three grout fans: B, D and F. each fan consisting of eight holes spaced at 45° around the circumference. Holes in fan D shall be drilled in staggered position compared to fan B and F.

Perform water pressure testing with packer setting at 7m from rock surface. After testing, the holes shall be grouted with cement-based grout type A if permeability is greater than 3 lugeon and type B if the permeability is less than or equal to 3 Lugeon. Final grouting pressure shall be at 45 bar for minimum 5 minutes or as directed by the Engineer during grouting. For detail of mix proportion and threshold values, see chapter 4.4.4.

After completing deep grouting, the outer 6-6.5m in rock of every hole shall be water pressure tested for leakage with packer setting 0.5-1.0m into rock. After testing, all holes shall be grouted with packer setting 0.5-1.0m into rock. If the water pressure test in any grouting hole shows water loss above 0.5 Lugeon, new holes shall be drilled at both sides at a "split spacing" pattern in each fan (or according to the Engineer's suggestion), tested and grouted. This procedure shall be repeated until all holes in each fan show permeability less than or equal to 0.5 Lugeon.

Upon completion of grouting all borehole collars shall be filled up by expanding mortar.

2.2.3 Design Quantities (only for primary holes)

Table 2: Bill of Quantity

S.N.	Section	Hole depth (m)	Number of Primary holes	Remarks
1	Bhaise adit plug	12	16	
2	CH3+557~CH3+727	12	32 E	
3	CH3+795~CH3+830	12	32 D	Additional holes (for Secondary and Tertiary and so on) shall be drilled as per the technical requirement shown on the design drawings.
4	CH4+395~CH4+505	12	32 C	
5	CH6+051~CH6+131	12	32 B	
6	Transition CH7+300	25	24	
		5	32	
	Total		200	

3. Construction Layout

3.1 Access Road

The existing access road will be used for grouting works, materials and equipments will be transported by truck.

3.2 Air Supply

In Headrace tunnel, one or two diesel air compressors with each capacity of 27m3/min will be used for drilling. Φ35 flexible hoses will be used for air supply to the drilling rigs.

3.3 Water Supply

The seepage water in the tunnel will be utilized for grouting admixture. Φ35 flexible pipes will be installed at the outlet of large seepage for water supply.

3.4 Power Supply and Lighting

The existing power cable and transformer will be used for grouting works. One diesel generator with capacity of 14KVA will be utilized for water pressure test. For lighting purpose, 350W LED lamp will be used.

3.5 Cement and Other Materials

The Cement and additives will be stored in the storage of concrete batching plant.

3.6 Grouting Platform

Grouting operation will be carried out on a dedicated platform. The grouting platform will be welded by steel and steel pipes of height 5m. The loader will move it along the working face of the tunnel. The structure of the platform is shown in the figure below.

Figure 1: Grouting Platform Sectional View

3.7 Communication

During the grouting works, the interphone and mobile phone will be used for contact each other.

4. Measures and Methodology

For Barrier Grouting

The specified construction procedures as the following steps:

- In Primary Holes:

  Drilling of Holes → Washing of Holes→ Water Pressure Test → Barrier Grouting

- In Further Round Holes:

  Based on Lugeon value in previous round grouting if Lugeon value is more than 0.5Lu then,

  Drilling of holes → Washing of Holes→ Water Pressure Test → Grouting

  For further round of grouting, time interval between water pressure test and previous round of grouting should be final setting time of grout of previous round.

  This procedure will be repeated until the Lugeon value of final round becomes less than or equal to 0.5Lu.

- For Further Stage of Grouting: Shallow Grouting:

  After completion of previous stage grouting, grouting in further stage will be done as following steps.

  Water Pressure Test → Grouting → Drilling of further round of holes based on Lugeon value in previous round (if Lugeon value is greater than 0.5Lu) → Water Pressure Test → Grouting.

  After completion of previous stage of grouting, water pressure test should be performed after final setting time of grout of previous stage.

  This procedure will be repeated until the Lugeon value of final round becomes less than or equal to 0.5Lu.

For Contact Grouting:

After completion of barrier grouting, contact grouting will be performed. Start of contact grouting refers to the completion of barrier grouting (deep as well as shallow grouting).

Procedure of contact grouting will be as following steps:

- For first round of contact grouting:

  Water Pressure Test → Contact Grouting at packer setting depth 0.5m within concrete portion

- For further round of contact grouting:

  Drilling of 2~3m long holes based on Lugeon value of previous round for contact grouting (if Lugeon value for contact grouting in previous round is more than 0.5Lu) → Washing of Holes → Water Pressure Test → Contact Grouting at packer setting depth 0.5m within concrete portion.

Time interval between previous round of contact grouting and Lugeon test for further round of contact grouting will be final setting time of previous round of contact grouting.

This procedure will be repeated until the Lugeon value of final round become less than or equal to 0.5Lu.

After completion of contact grouting, holes will be sealed by expandable mortar.

4.1 Drilling of Holes

The location, depth, inclination angle and orientation of the barrier-grouting/contact grouting holes shall be strictly in compliance with the construction drawing or the Engineer's direction. For each of the grouting holes, its location shall be surveyed and set out by the surveyor in accordance with the construction drawing and then the drill rig shall be accurately put in its place with the help of the survey instrument and geological compass.

The grouting holes will be drilled mainly by using the percussion drill with Model SKQ 100B. All of the Grouting holes shall be 76mm in diameter. In order to fix the drilling rig in the headrace tunnel, the heavy-duty scaffolding shall be erected and securely attached and fastened to the rock. Also, some facilities and tools shall be provided for safety purpose of the equipment and manpower. The drill rigs will be shifted by using some chain hoists.

Drilling of primary holes (approximately 90%) is completed. After start of barrier grouting in one of the grouting station, drilling of remaining primary holes will be accomplished parallelly in another grouting station. For further round of holes based on Lugeon value in previous round holes, 5~6 12m-long holes can be drilled in one day. 2~3 25m-long holes can be drilled in one day. Similarly, 7~8 5m-long holes can be drilled in one day by this drill rig.

For time efficiency, we are trying to bring mounted drilling boom (Jumboo) in rent from Nepali company. One of our sub-contractor is trying for it.

4.2 Washing of Holes

Upon completion of drilling of the grouting hole, it shall be washed with pressure water till the return water becomes clear and free from any rock cuttings, debris, mud or other deleterious materials.

Immediately after cleaning of the hole is completed, the collar of cleaned hole shall be capped or plugged with wooden plug or plastic sacks to protect them from entry of dirt, mud, wasted grout, surface runoff or other matters.

4.3 Water Pressure Test

Prior to grouting, water pressure test shall be carried out for every grout hole. The maximum Pressure for water pressure test shall be 80% of the grouting pressure and not more than 1.0Mpa, each pressure shall be maintained for at least five minutes.

The holes will be water pressure tested with three-pressure and five-stage method, or decided by the Engineer.

4.3.1 25m Long Holes

Two stages: The first stage is 17~18m long and will be water pressure tested for leakage with single packer setting 7~8m inside the rock surface. The second stage is 6~6.5m long and will be tested for leakage with outer packer setting 0.5-1.0m into rock.

4.3.2 12m Long Holes

Two stages: The first stage is 7m long and will be water pressure tested for leakage with single packer setting 5m inside the rock surface. The second stage is 5m long and will be tested for leakage with outer packer setting 0.5-1.0m into rock.

4.3.3 5m Long Holes

One stage: The hole will be Water Pressure Tested for leakage with single packer setting 0.5-1.0m into rock.

4.3.4 2m Long Holes (contact grouting)

After completion of barrier grouting, Lugeon test for contact grouting will be done at packer setting depth 0.5m from outer face of tunnel (in concreting portion).

4.4 Grouting of Holes

4.4.1 Selection of Grouting Pumps and Materials

In one face, maximum 5 pumps will be used in order to do simultaneous grouting. In another face 2 pumps will be used. According to requirement, grouting set can be adjusted i.e. number of grouting set can be increased. Selection of grouting pump will be based on required final pressure of barrier grouting. I.e. if required final pressure is low, in that case we will use 22kw grouting pump, if required pressure is high, in that case 55kw and 90kw grouting pump will be used even though all grouting pump can be regulated as required pressure. Grouting pumps Model SGB6-10 and/or XPB90 will be used in barrier grouting. OPC cement and/or Micro Fine cement (in bags) will be used. Sika intraplast EP expansion agent will be used with dosage equal to 1~2% of cement. According to site observation and requirement, other materials (Accelerator, sand etc.) will be used according to the Engineer suggestion. For inter-connected holes, more holes will be grouted simultaneously. If number of interconnected holes is more than simultaneous grouting holes, packer will be used to block grout from other holes. For detail of mix proportion see chapter 4.4.4.

4.4.2 Grouting Method and Sequence

In general, barrier grouting of any hole shall be carried out by the ascending stage. The length of each stage to be grouted shall be same as the length for water pressure test, and also can be reduced or increased as necessary under the special circumstances, with the consent of the Engineer. The packer shall be fixed at the appropriate position for each grouting stage.

For 25m and 12m long holes, the grouting sequence is as the following:

i. Lugeon test for first stage with single packer.

ii. Grouting for first stage with single packer.

iii. Drilling of further round of holes, Lugeon test and grouting based on result of Lugeon value of previous round (if Lugeon value is greater than 0.5Lu).

iv. Step iii will be repeated until the Lugeon value of final round become less than or equal to 0.5 Lu.

v. Lugeon test for second stage with single packer.

vi. Grouting for second stage with single packer.

vii. Drilling of further round of holes, Lugeon test and grouting based on result of Lugeon value of previous round (if Lugeon value is greater than 0.5Lu)

viii. Step vii will be repeated until the Lugeon value of final round become less than or equal to 0.5 Lu.

ix. After completion of barrier grouting (deep as well as shallow), Lueon test will be performed for contact grouting. Then contact grouting packer setting at 0.5m in concrete portion will be done.

x. Based on Lugeon value in previous round of contact grouting, further round of 2~3 m long holes will be drilled (if Lugeon value in previous round hole for contact grouting is more than 0.5 Lu). Then Lugeon test and grouting will be done.

xi. Step x will be repeated until the Lugeon value of final round of holes for contact grouting become less than or equal to 0.5Lu.

xii. After completion of contact grouting

4.4.3 Grouting Steps

(1) Barrier grouting shall commence with a grout with water/cement ratio of 1.2:1 by weight. The pressure shall be gradually increased to the maximum specified pressure.

If the maximum specified pressure is achieved, the grouting shall continue as per the procedures stating from A to C:

A. If grout-take raises volume stopping criteria, then go to Step (2);

B. If refusal has been reached (Refusal criteria maintain final grouting pressure with zero flow for 5 minutes or as decided by the Engineer during the grouting works), then the grouting shall end.

(2) If refusal of grout cannot be achieved in Step (1) as defined above, the above procedures shall be repeated with water/cement ratio of 1:1 by weight.

(3) If refusal of grout has still not been reached in Step (2) as defined above, the procedure shall be repeated with the grout with water: cement ratio of 0.8:1 by weight.

(4) If refusal of grout has not still been reached in Step (3) as defined above, the grouting has to terminate when the total grout-take with water-cement ratio of 0.5:1 by weight rises to stopping volume criteria. Stopping volume criteria is given in chapter 4.4.4.

(5) In case of grouting interruption, after a period of at least 2 days, a new hole shall be drilled adjacent to the previous hole as directed by the Engineer then grouting will be started with aforementioned sequence of grouting.

4.4.4 Volume Stopping Criteria

If hole have Lugeon value greater than 8.0 then volume stopping criteria will be 3000 ltr (this is updated value before it was also 2000ltr) but for holes below 8.0 Lugeon, volume stopping criteria will be 2000ltr.

Table 3: Mix Proportion of Grout Based on Lugeon Value

Lugeon Value	Cement Type	W/C	Admixture (%)	Volume criteria (litr)
Less than or equal to 3	MFC (B)	1.2:1	2	300
		1:1	1.5	300
		0.8:1	1.5	400
		0.5:1	0	1000
Greater than 3 To 8	OPC (A)	1.2:1	2	300
		1:1	1.5	300
		0.8:1	1.5	400
		0.5:1	0	1000
Greater than 8	OPC (A)	1:1	1.5	300
		0.8:1	1.5	500
		0.5:1	0	2200

According to site condition, grouting including accelerator / sand mortar will be done based on the Engineer's suggestion.

4.4.5 Grouting Pressure

Table 4: List of Grouting Pressure

Location	Packer Setting (m)	Pressure (bar)
Intake lining transition	5.0m	10
	0.5-1.0m	10
haise Plug	5.0m	30
	0.5-1.0m	15
CH3+557 to 3+727	5.0m	30
	0.5-1.0m	30
CH3+795 to 3+830	5.0m	30
	0.5-1.0m	30
CH4+395 to 4+505	5.0m	30
	0.5-1.0m	30
CH6+051 to 6+131	5.0m	30
	0.5-1.0m	30
Transition from unlined to lined tunnel (25m holes)	7.0m	45
	0.5-1.0m	45
Transition from unlined to lined tunnel (5m holes)	0.5-1.0m	30

For contact grouting, pressure will be same as aforementioned pressure for shallow grouting (packer setting at 0.5~1m in concrete portion) unless the Engineer instruct other pressure criteria.

4.4.6 Treatment to Exceptional Cases

If, during the grouting operation for one stage of a grout hole, the grout is found flowing and leaking out from the adjacent holes, the following measures shall be taken to make treatment:

A. Firstly, to suspend the grout injecting and install one grouting packer (blocker) into the interconnecting hole to the same depth as that of holes where the grout injection is being done,

B. Then simultaneous grouting in leaking holes (in two or more than two holes) will be done. Simultaneous grouting will be done by more set of grouting equipment. In one face of grouting, maximum 5 set of grouting will be managed.

C. If there are still other holes of leaking then those holes will be blocked by packer (in barrier grouting)/ blocker (contact grouting) then grout injection can be continued.

D. Blocked holes will be grouted after completion of grouting in previous grouting holes. If leakage of grout in interconnecting holes has not stopped yet, then the packer inside the interconnecting holes shall be lift up for 1.0~4.0m, or the packer can be fixed at the collar of the interconnecting holes, then grout injecting can continue. After completion of grouting of this hole, an additional hole shall be drilled nearby the interconnecting hole and grouted.

4.4.7 Procedure of Contact Grouting

After completion of barrier grouting packer setting at 0.5~1m in rock, lugeon test will be performed for contact grouting packer setting at 0.5m in concrete from surface. Based on Lugeon value grouting will be done. Procedure and mix proportion of contact grouting will be same as barrier grouting. Lugeon value criteria for mix proportion and stopping criteria (pressure as well as volume) will be also same that of barrier grouting. If Lugeon value is more than 0.5 Lugeon then 2m long holes will be drilled for further round of holes. Grouting sequence in further round of holes will be also same as that of barrier grouting. But blocker (10 cm) will be used in contact grouting instead of packer.

4.5 Sealing of Holes

After completion of contact grouting, hole will be sealed by expandable cement mortar. Procedure of sealing of holes by expandable mortar is as follows.

A. Mix the dry mortar at site according to required quantity as mix design W/C 0.3.

B. Making a wooden flat-headed tamper, the diameter of the tamper is smaller than the diameter of the grouting hole, and the length is 20 cm longer than the backfilling depth;

C. Backfilling about 5-10cm each time, push the mortar to the bottom of the hole with the tamper, and compact it, then backfilling next layer.

D. After finished, compact and smooth the surface, paste the tape on the surface to keep moist.

5. Construction Schedule

Please refer to the updated general construction schedule. The partial grouting schedule and its updates shall be submitted to the Engineer for review and comment, every two weeks.

6. Resource Allocation Plan

6.1 Manpower

Table 5: List of Manpower

SN	Manpower Description	No	Remarks
1	Grouting Expert	2	At least 1 will be on site
2	Grouting Leader	2	1 per face
3	Grouting Coordinator	1	
4	Geologist/Engineer (Quality control)	2	1 per face
5	Site Shift Engineer (site supervision)	2	1 per face
6	Foreman	2	1 per face
7	Safety officer	2	Frequently site visit , 1 per face
8	The electrician	2	Frequently site visit , 1 per face
11	Operator	12	6 per face
12	Survey	3	As required
13	Driller	10	5 per face
14	Labor	24	12 per face
Total		64	

Grouting expert will fully control grouting work. He will be present until the completion of grouting work. Grouting leader will manage site according to our method statement. He will be commanded for progress of grouting work by grouting expert and Chief Engineer. Grouting coordinator will coordinate among all related person and site work. He will be responsible for QA/QC test, improvisation of grouting work coordinating with grouting expert, grouting leader, geologist and other respective personnel. Geologist / Engineer will be managed as one per face. Another Geologist will generate report for grouting. He will be responsible for general command. He will visit site frequently. According to speed of work and new revised schedule (partial schedule may change to increase grouting work progress), manpower list can be revised according to work situation but key manpower for grouting will not be changed.

6.2 Equipment & Machinery

Table 6: List of Construction Equipment & Machinery

SN	Device name	Model	No.	Remarks
1	Drilling platform	6m*5m*5m	2	1 per face
2	Percussion drill	SKQ100	4	2 per face
3	Core drilling Machine	GXY-1	2	As required
4	Air compressor	Atlas Copco30 m^3/min	3	Diesel
5	Water pump	Atlas Copco 2.5kw, 5bar	4	
6	Sewage pump	7.5kw	2	
7	High speed colloidal mixer	HS-ZJ300	5	
8	Compact colloidal Series	CG-600	1	Turbomixture
9	High-pressure Grout Plant	CG-460	1	
10	Mixing barrel	200L	5	
11	Agitator	400L	5	
12	High speed grouting pump	SGB-6-10	5	22kw
13	High speed grouting pump	YE2 VP280 M-6	2	55kw
14	High speed grouting pump	XPB90	2	90kw
15	High speed grouting pump	YTB-1	5	37kw
16	Packer and auxiliary	Φ75 mm, 1m long	65	Hydraulic
17	Blocker	Φ75 mm, 10 cm long	20	Mechanical
18	Hydraulic hoses	Φ25mm	150	Meter long
19	Generator	14KVA	1	Diesel
20	Automatic grouting data reader		4	
21	Automatic Lugeon test data reader		2	

SN	Device name	Model	No.	Remarks
22	Pressure Gausses		20	
23	Connectors and other spare parts		Enough Number	
24	Safety first-aid kits		One per site	

Since we have planned 5 set of grouting in one face and 2 set of grouting in another face, colloidal mixture are sufficient. Number of grouting pumps is more than number of colloidal mixture for back up. Pressure and pumping rate of high pressure pumps can be regulated reducing motor speed of pump. It is easy to regulate according to desired pumping rate and pressure. All pumps are progressive cavity, pulse free type and capable of handling thin and viscous grouts with no pulse. Turbomixture (CG- Compact Colloidal Series) and CG-460 high-pressure grout plant will be brought here soon (already ordered). Turbomixture (CG-600) and high-pressure grout plant (CG-460) have automatic recorder. And Lugeon test recorder can also be used as grouting recorder. So grouting recorder is sufficient for two faces.

XPB-90 high speed grouting pumps and YE2 VP280 M-6 high speed grouting pumps will be used in HT4 where required final pressure is 45Bar. YTB-1 grouting pump can be also used in this grouting station. YTB-1 high speed grouting pump will be used in HT3 where required final pressure is 30 Bar. In this grouting face, SGB-6-10 pump can be also used. Normally, SGB-6-10 pump will be used for grouting if required final pressure is low. Pressure reading will be taken by analogue system as well as digital system. Turbomixture (CG-600) and high-pressure grout plant (CG-460) will be used in second face of grouting where two set of grouting will be used. Grouting pump and connected agitator will be placed within 30 meter from the grouting holes.

Two pressure gauges will be used for the grouting plant among which one at the pump and another in grouting recording unit (digital). Pressure recording unit shall be connected to the pressure line from the grout pump. The dial size of the pressure gauge will be more than 150 mm...

According to site work progress and requirement, other machines will be added. For detail of equipment, see Annex section.

7 Quality Assurance Measures

Before construction, the department and the Engineer will do joint work together to discuss the two sides recognized drilling records, the hole form, pressurized water permeability coefficient table form, type and the grouting parameters, grouting form and other forms to formulate the required decision and solution. The site personnel will record according to the form and find out the Engineer to sign it on time and for next day, the first day record will be signed before leaving work. Without the approval of the Engineer, the next procedure will not be carried out.

The machine of the drill will meet its corresponding technical requirements which will be conveniently located to ensure the hole position and hole direction. The drill's depth will meet the requirements of the hole depth. The pneumatic drill will have a silencer and dust removal device. The mixing equipment will be equipped with high speed pulping machine and the corresponding filtration device will be configured. The pressure of grouting equipment will meet the technical requirements, the operation will be stable, the swing range will be small and the piston will not leak during the mixing process. The test and recording equipment will adopt the end- product and the former will be checked against the predefined quality standards and the pumping rates will be set to prevent any malpractice to affect construction quality.

The construction process in terms of inspection, testing and acceptance shall be performed in line with all relevant procedures. Sinohydro management team will comply with the entire program for QA/QC. Grouting Expert Mr. Yan Hai Bo will fully control grouting work. Grouting Coordinator Shadananda Gautam, Geologist Suraj Giri will be also responsible for quality control for grouting work. (See attached C.V.).

8 Safety Guarantee Measures

Before construction, we will carefully check assignments section of the roof stability of surrounding. During construction, professional electrician will check power system and lighting system for construction acceptance and he will prevent from electric shock hazards. During the operation of electrical equipment, construction personnel shall wear insulating rubber and insulating gloves. Power line and lighting electricity line in tunnel construction will be in separate arrangement, we will not do wire winding at any cost and we will install leakage protector.

For construction, machinery and equipment will be set in safe location so that surrounding rock will be stable of that area. Mixer, vibrator and vibrating rod equipment will be inspected thoroughly before they are used. By the department of homeland security (safety department), all construction personnel will be provided safety education to improve the safety awareness. We will set the hopper vehicle backing to protect and prevent vehicle from damage. Construction vehicle moving inside the tunnel and close to the working face must move carefully and at slow speed. Construction personnel shall wear safety helmet with chinstraps, operation of electrical equipment construction personnel shall wear insulating rubber and insulating gloves. In case of any incident, we have made following plan.

i. **In normal case**: Inform to Chinese supervisor and use of first aid box properly.

ii. **Slight Injury**: Inform to Chinese supervisor then use of first aid and Chinese supervisor will inform to safety department and our clinic. Our clinic will give first aid treatment.

iii. **Serious Injury**: At first inform to Chinese supervisor then use of first aid and Chinese supervisor will inform to safety department and comprehensive department. We will manage medical staff and give medical treatment and inform site manager or commercial manger. Site manager or commercial manager will manage ambulance then take Patient to Sigati hospital / Charikot Hospital/ Kathmandu Hospital for further treatment.

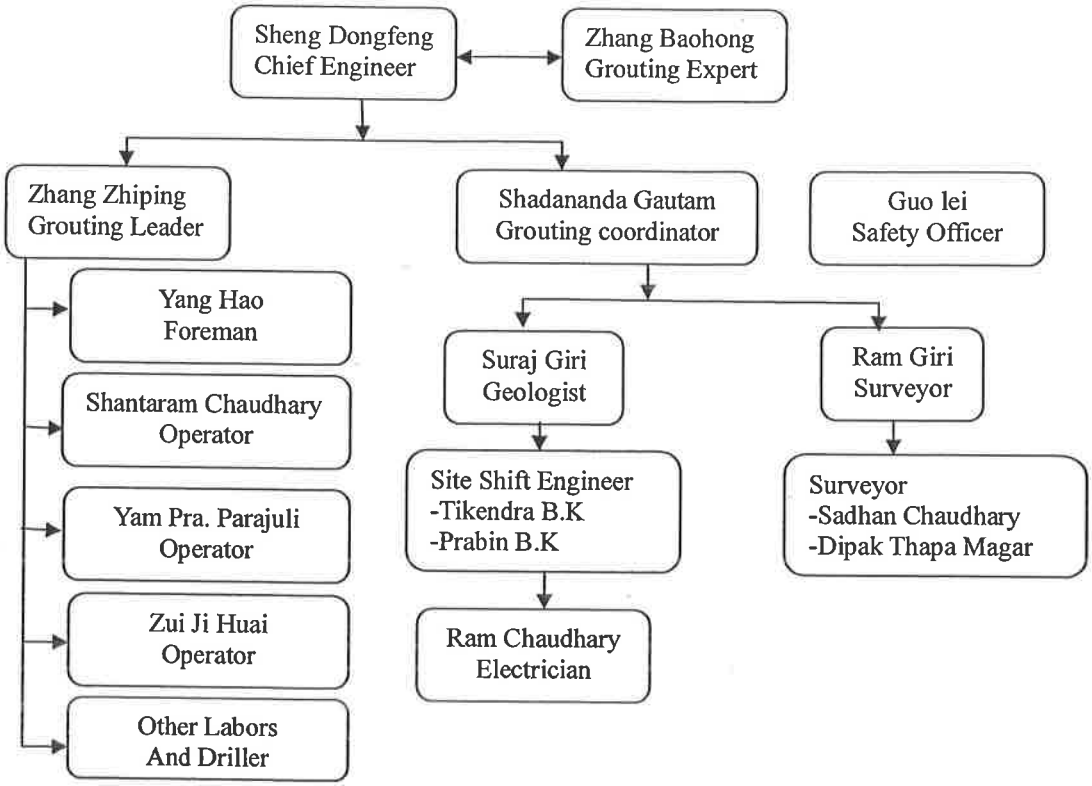
iv. **Very Serious Injury**: At first inform to Chinese supervisor then use of first aid and Chinese supervisor will inform to safety department and comprehensive department. We will manage medical staff and give medical treatment and inform site manager or commercial manger. Site manager or commercial manager will inform to Project manager. Project manager will manage air ambulance for taking patient to Kathmandu hospital for his treatment.

For risk assessment program see annex chapter.

9 Construction Work Discipline

In the main construction site, adjacent to the working face, the high-risk zones and the main access points; we shall place suspension eye-catching safety warning signs and signals. The drill pipe, wind water pipe, cement and waste cement bags will be arranged neatly, and marked according to the standard. Route of pipe lines for air, water and electricity shall be used flat, straight, smooth and orderly at construction site. During the whole grouting operation, we shall keep the site clean and tidy and the waste water and waste slurry will be discharged to the designated place. We will strictly maintain a functional waste water collection system from the site.

10 Organigram for Each Face of Barrier Grouting



Number of labors, driller and operator will be managed according to grouting set in each grouting face. In each face of grouting, organigram will be same as aforementioned organigram. Difference is only personals.

11 QA/QC Test

All QA/QC test will be performed one time in each shift for each mix ratio of grout.

11.1 Bleeding Test:

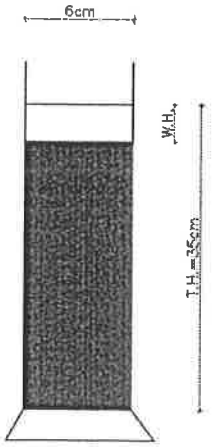


Figure 2: Bleeding Test Apparatus According to Widmann

Bleeding of grout refers to the separation of solid particles from the fluid. Above figure Shows a measuring method recommended by Widmann where bleeding is defined as the height of clear water (W.H.) in percentage of the total height (T.H). One liter of grout is poured into a cylinder with a diameter of 60mm, which gives a sample height of 35cm. After 1hr time, the height of clear water is measured.

11.2 Viscosity (Marsh Cone) Test

Reporting viscosity makes it possible for grouting leader to observe sudden changes in the mix viscosity and take corrective action when necessary. Funnel viscosity is the ratio of the speed of the slurry as it passes through the outlet tube (share rate) to the force (weight of the slurry) causing the slurry to flow (shear stress). Procedure of the Marsh cone test is

- A marsh cone will be attached to a stand.
- Closing the nozzle (having diameter 10mm) by finger, a certain amount of material (to be tested) will be poured in to the cone. This amount may vary from 0.8 liter to 1.7 liter according to the Engineer advice. Initial filling height in cone will be noted as H_0.
- Removing the finger, nozzle will be opened and a stop watch will be started.
- Flowing volume from nozzle will be recorded. And final filling height will be noted as H_f. By video recording the flow, any value may be chosen.

11.3 Setting Time (Initial and Final)

To address the waiting time interval between one grouting stage and the forthcoming permeability testing, samples shall be collected and tested for their strength and setting time.

- Prepare a paste of 300 grams of cement with 0.85 times the water required. The time of gauging in any case shall not be less than 3 minutes not more than 5 minutes and the gauging shall be completed before any sign of setting occurs.
- Count the time of gauging from the time of adding water to the dry cement until commencing to fill the mould.
- Fill the Vicat mould with this paste making it level with the top of the mould.
- Slightly shake the mould to expel the air.
- In filling the mould the operator hands and the blade the gauging trowel shall only be used.

Initial Setting Time

Immediately place the test block with the non-porous resting plate, under the rod bearing the initial setting needle.

- Lower the needle and quickly release allowing it to penetrate in to the mould.
- In the beginning the needle will completely pierce the mould.
- Repeat this procedure until the needle fails to pierce the mould for 5 + 0.5mm.
- Record the period elapsed between the time of adding water to the cement to the time when needle fails to pierce the mould by 5 + 0.5mm as the initial setting time.

Final Setting Time

- Replace the needle of the Vicat apparatus by the needle with an annular ring.
- Lower the needle and quickly release.
- Repeat the process until the annular ring makes an impression on the mould.
- Record the period elapsed between the time of adding water to the cement to the time when the annular ring fails to make the impression on the mould as the final setting time.

11.4 Density Test by Liquid Hydrometer

To determine the grout density, hydrometer will be used. Procedure of measuring density of grout is given as

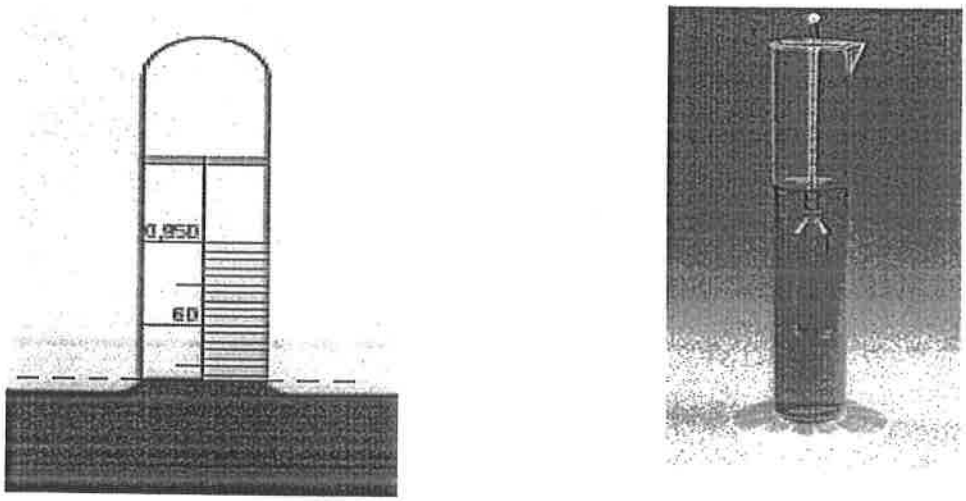


Figure 3: Liquid Hydrometer to Measure Density of Grout Liquid

- A suitable hydrometer for grout (liquid) and a hydrometer jar having correct diameter to eliminate edge effects from surface tension and enough to fit the hydrometer when it floats will be taken.
- In order to minimize the air bubbles in the jar, grout liquid sample will be poured slowly down the side of the jar.
- Grout (Liquid) sample will be stirred gently to dispel any formed bubbles in the jar.
- Hydrometer by the top of the stem will be hold and will be lowered into the liquid. After getting in equilibrium position hydrometer will be released.
- After resting the stem between finger and thumb, hydrometer will be pushed down a few millimeters below equilibrium then it will be released. After releasing, it should rise steadily and should settle to its position of equilibrium.
- Reading corresponding to the plane of intersection of horizontal liquid surface and the stem will be taken. Then according to scale needed, density of grout will be calculated.

12 Grouting Over View Report

The use of the three-page power point report shall be used (first page for permeability overview, second page for grout consumption and third page for possible interconnections).The report shall be distributed daily by e-mail to all responsible parties. E-mail titles shall adopt the following structure:
GL (GL for long barrier grouting or GS for short barrier grouting or GC for contact grouting)-Barrier (or Contact Grouting Report_Block DE(or C or B or A)_U/S(or D/S)_(X+XXX to X+XXX) if YYYY.MM.DD(date)
e.g. GL-Barrier Grouting Report_Block DE_U/S_(3+558 to 3+561) of 2019.05.24.
Grouting over view report (3 page power point report is in Annex C: Format.

Naming of holes will be done as following:

i. Deep Barrier Grouting : (GL-Chainage-Stage of Grouting-Hole Number)
ii. Shallow Barrier Grouting : (GS-Chainage-Stage of Grouting-Hole Number)
iii. Contact Grouting : (GC-Chainage- Hole Number)

For example,
GL-3558-I-01, GS-3558-I-01 and GC-3558-01

Equipment

Appendices

Annex A: Equipment Technical Specification

Grout Pump

Enough grouting pump are available in site. All grout pumps are pulse free type, capable of handling thin and viscous grouts with no pulse. All grout pumps will be equipped with a pressure regulating device securing maximum grouting pressure with +/-10% of the required pressure. Company certificate of following grouting pump will be submitted before starting of grouting. Grouting pressure can be regulated in all pumps automatically. Grouting pumps specification is as follows.

XPB-90 High Pressure Grouting Pump

Model NO.	**: XPB-90**
Application	: High-Pressure Curtain Grouting
Diameter of Plunger	: 60mm
Specification	: 1600*1630*1200
Origin	: China
Max. Head	: 110m-150m
Max. Capacity	: 100-200 L/min
Pressure Medium	: Water
Type	: Handheld
Certification	: CE, ISO, RoHS

Product Description of XPB-90 High Pressure Grouting Pump

This product is designed according to the market demand of high-pressure grouting pump. Its combined fluid on the pump head, the motivation to use needle bearing type transmission, low noise, low temperature raises, guarantee continuous operation 24 hours a day. Suitable for foundation treatment of high-pressure rotary jet grouting, curtain grouting, soil retaining cofferdam, mine well plugging, the barrel wall, slope anchorage. etc.

Figure: XPB 90 EX High Pressure Prouting Pump (90 kw)

Technical Specification of XPB 90 EX high-Pressure Grouting Pump

Figure: Technical Specification of XPB 90 EX High Pressure Grouting Pump

Table: Technical Specification of Grouting Pump (XPB 90 EX)

S.N.	Description	Specification	S.N.	Description	Specification
1	Plunger diameter	60mm	5	Discharge Pipe Dia.	16~25mm
2	Effluxing flow rate	119L/min	6	Pated Power	90kw
3	Date of Production	2014 April	7	Working Pressure	37Mpa
4	Manufacturing Factory Number	2014 258240	8	Executive Number	Q/12YJ3933-2010

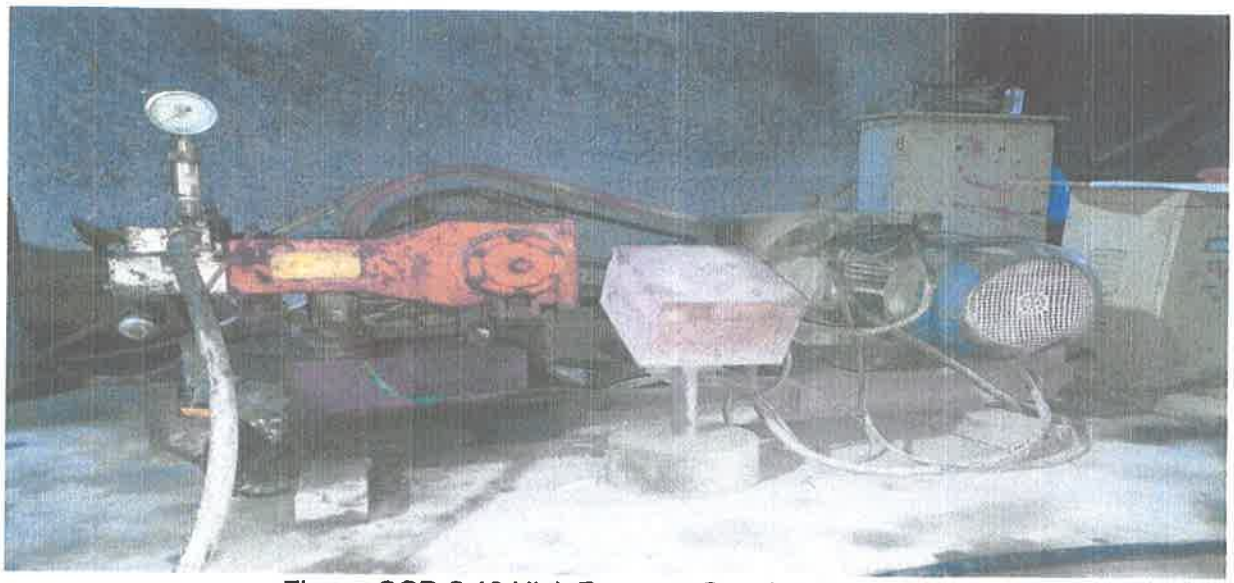


Figure: SGB-6-10 High Pressure Grouting Pump (22kw)

Technical Specification of High-Pressure Grouting Pump SGB-6-10

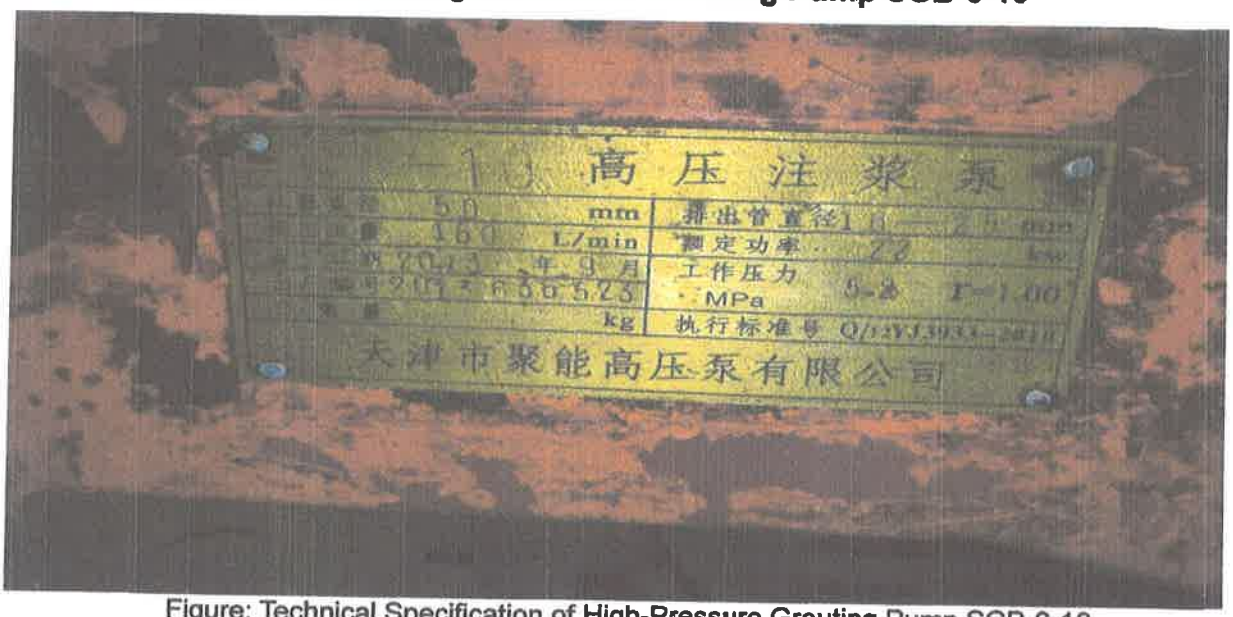


Figure: Technical Specification of High-Pressure Grouting Pump SGB-6-10

Table: Technical Specification of High –pressure Grouting Pump SGB-6-10

S.N.	Description	Specification	S.N.	Description	Specification
1	Plunger diameter	50mm	5	Discharge Pipe dia.	16~25mm
2	Effluxing flow rate	160L/min	6	Rated Power	22kw
3	Date of Production	2013 Sep	7	Working Pressure	5.8Mpa
4	Manufacturing Factory Number	2013 636523	8	Executive Number	Q/12YJ3933-2010

Figure: High Speed Grouting Pump YE2 VP280 M-6 (25kw)

Technical Specification of High-Speed Grouting Pump YE2 VP280 M-6

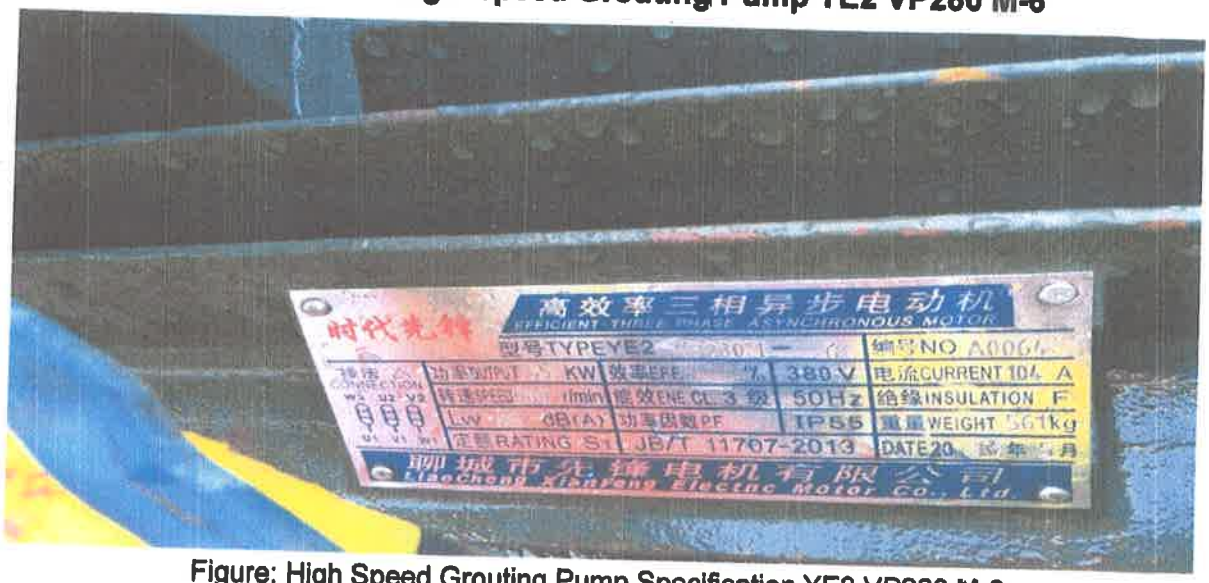


Figure: High Speed Grouting Pump Specification YE2 VP280 M-6

Table: Technical Specification of Grouting PumpYE2 VP280 M-6

S.N.	Description	Specification	S.N.	Description	Specification
1	Rated Power	55kw	5	Current	104 MPa
2	Model number	YE2 VP280M	6	Voltage	380V
3	Serial Number	A0064	7	Net Weight	561 Kg
4	Manufactured date	2013 May	8	Speed	980 rpm

Technical specification of high-speed grouting pump YTB-1

Figure: High Speed Grouting Pump YTB-1

Technical Specification of Grouting Pump (YTB-1)

S.N.	Description	Specification	S.N.	Description	Specification
1	Rated Power	37kw	4	Pre. capacity	15MPa
2	Model number	YTB-1	5	Mfd. date	03/2019
3	Serial Number	Q/12YJ3933-2010	6	Discharge rate	107 L/min

Packer and auxiliary

Inflatable grout packer model	: 34B
Total Length	: 140cm
Flexible packer length	: 100cm
Minimum (at rest) Diameter	: 75mm
Maximum (inflated) diameter	: 130mm
Pressure Capacity	: 12.5 MPa

Figure: Packer Auxiliary

Both ends of packer are fixed. As inflation pressure is increased the rubber element expands much like a balloon. This is larger center tube type of grouting packer.

Figure: Blocker (75mm)

Specification of Blocker

Flexible packer length	: 10cm
Minimum (at rest) Diameter	: 75mm
Maximum (inflated) diameter	: 130mm
Pressure Capacity	: 12.5 MPa

Hydraulic Hoses

Model	: YUN HE STEEL WIRE BRAIDED HYDRAULIC HOSES
Code	: 1P-Ø
Cover	: Black, oil, abrasion and weather resistant, thin synthetic rubber
Reinforcement	: Two braids of high tensile steel wire
Temperature range	: -40°C to 120°C
Working Pressure	: 16.5 MPa

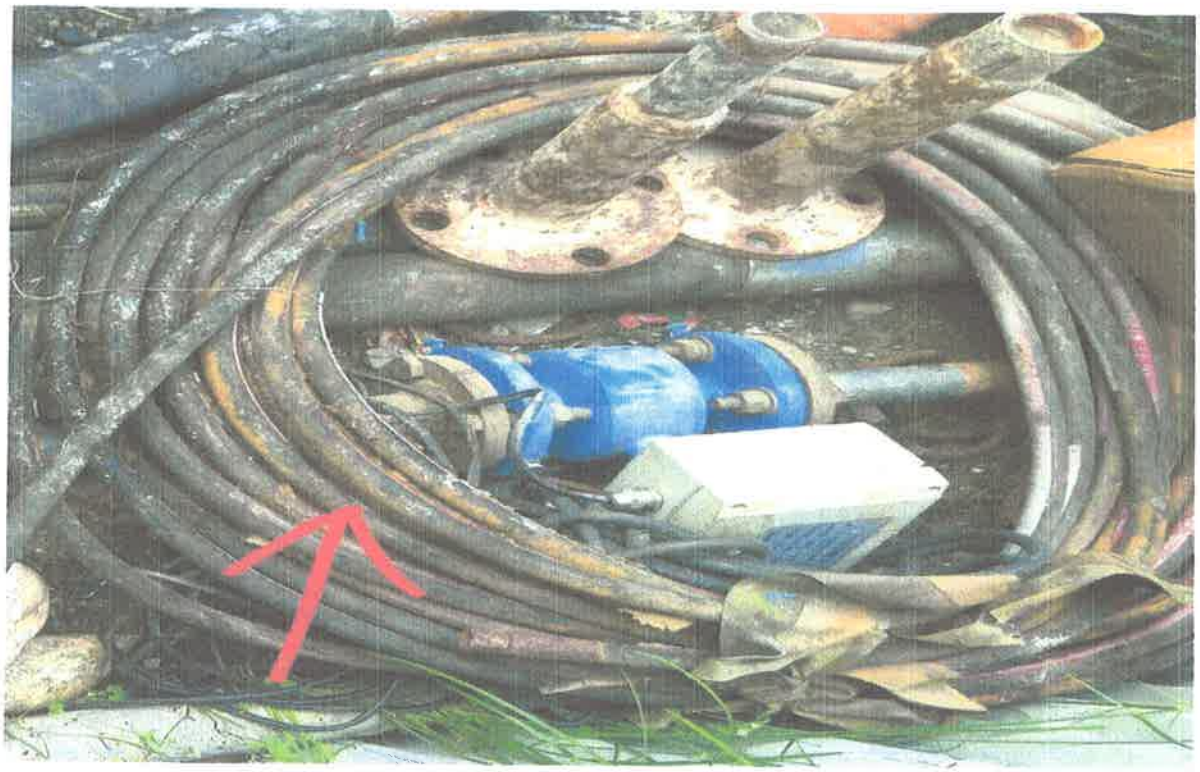


Figure: Hydraulic Hose

High-speed Colloidal Grout Mixer (HJB-700)

Figure: High-Speed Colloidal Mixture

Description

The HJB-700 is a high-speed colloidal grout mixer which consists of motor, reducer, mixing tank and storage tank. It is capable of mixing grouts with water/ cement ratios between 0.4 and 10 by weight.

The mixer is light in weight, easy to install and transport, easy to operate and use, and is one of the essential engineering equipment.

Technical parameter

Table: Technical Specification for Colloidal Mixture

Description	Technical data
Motor	5.5kw
Rotate speed	1400r/min
Capacity of mixer	10m3/h
Overall dimensions	1700mm×950mm×1700mm
Gross weight	500kg
Origin	Made in China

Figure: Automatic Lugeon Test Data Reader

Figure: Automatic Grouting Data Reader

Technical specification of percussive drilling rig (SKQ100)

Figure: Percussive Drilling Machine

Table: Technical Specification of Percussive Drilling Machine

S.N	Description	Feature
1	Brand name	hongwuhuan
2	Air Consumption	12m3/min
3	Weight	245kg
4	Drilling Diameter	60~100mm
5	Maximum lifting power	9600N
6	Engine	Pneumatic
7	Drilling Bit	Diamond bit
8	Power type	Air compressor
9	Air Motor Capacity	4kw
10	Pressure Capacity	0.5MPa
11	RPM value	3200r/min

Technical Specification Core Drilling Machine (GXY-1)

Figure 1: Core Drilling Machine GXY-1

Table: Technical Specification of Core Drilling Machine (GXY-1)

Description	Technical data
Motor	11kw
Drilling bit rotation	61.163-338.654r/min
Pulling power	25KN
Overall dimensions	1450mm×970mm×1280mm
Gross weight	500kg
Origin	Made in China
Mfd. Date	1st 2015
Drilling Capacity	30.150m deep

This core drilling machine will be used only when the Engineer instruct for grout sample test.

Figure: Air Compressor (Atlas Copco 30m3)

ChemGrout

CG-600
Compact Colloidal Series

The CG600/8CF combines the latest advances in colloidal grouting in a compact design. These field proven grout plants feature ChemGrout's 8 cubic foot capacity "Turbomixer", along with a rotating bridge breaker, nine cubic foot capacity vertical shaft paddle agitator, and a 3-stage size 6 closed throat progressive cavity pump. Mixer and pump are mounted on a single skid (transportable by pick-up truck) for quick, easy set-up and immediate operation.

Specifications

PUMP

Pump Type	3L6 progressing cavity
Output/Pressure	20 gpm, 261 psi

COLLOIDAL MIXER

Mix Tank	8 c.f. with bottom cleanout
Mixing Pump	2 x 3 x 6 diffuser-type centrifugal
Holding Tank	9 c.f. or 13 c.f. paddle agitating

PHYSICAL SPECIFICATIONS

Air

Weight	~1200 lbs.
Size	88"L x 34"W x 59"H
Power Required	300 cfm, 100 psi (air)

Hydraulic

Weight	~1200 lbs.
Size	88"L x 34"W x 59"H
Power Required	Dual Circuits, 12/12 gpm, 2000 psi

POWER PACKS

Electric/Hydraulic

Weight	Varies
Size	Varies by Voltage
Power Required	3 Phase, several voltages available

Diesel/Hydraulic

Weight	~1750 lbs.
Size	74"L x 34"W x 37"H
Power Required	Diesel/electric start

CG-460 High-Pressure Grout Plant

The versatile CG460/2X8 is a skid mounted, high-pressure grout plant that is designed to mix and pump neat cements at high-pressures. It features two high shear colloidal 70 gallon mixing tanks, and a double acting, high-pressure plunger type grout pump. Dual 70 gallon colloidal mix tanks allow for independent mixing of flushing and structural grouts. Each mixer uses variable speed, high-efficiency, high shear disks, rotating at speeds up to 3,000 rpm that provides rapid and thorough mixing. The grout pump is a double acting, positive displacement plunger style pump. The CG460 is available in a number of power options listed below.

Specifications

PUMP

Pump Type	2 x 8 Double acting plunger
Output/Pressure	15 gpm (57 lpm), 2000 psi (138 bar)

PHYSICAL SPECIFICATIONS

Air

Weight	~1400 lbs.
Size	96"L x 40"W x 56"H
Power Required	375 cfm, 100 psi (air)

Hydraulic

Weight	~1320 lbs.
Size	108"L x 40"W x 56"H
Power Required	3 Circuits, 6/6/16 gpm, 2400 psi

POWER PACKS

Electric/Hydraulic

Weight	1240 lbs.
Size	85"L x 36"W x 46"H
Power Required	3 Phase, several voltages available

Diesel/Hydraulic

Weight	~1450 lbs.
Size	85"L x 36"W x 46"H
Power Required	Turbo Diesel Engine

ChemGrout®

The World's Widest Selection of Grouting Equipment

Heavy Construction

- Slurry Trenches & Walls
- Undersealing
- Tie-Backs
- Tendons
- Ground Anchors
- Foundations

Marine/ Offshore

- Bridges & Foundations
- Dam Grouting
- Underwater
- Erosion Protection

Mining & Tunneling

- Void Filling
- Waterproofing
- Rock Bolts and Anchors

Colloidal Grouting Equipment

Featuring ChemGrout's "TurboMix" Colloidal Mixer

Material

ALCOFINE
MICRO MATERIALS

Alccofine 1109SS*

Cementitious micro-fine injection grout for soil stabilisation

DESCRIPTION

Alccofine 1109SS* is cementitious micro-fine injection grout powder. It is based on unique PSD technology to facilitate effective filling of very fine cracks, pores and voids. It has extremely finer particle size compared to other hydraulically setting materials like OPC. It has Fineness by blaine of more than 9000 cm^2/gm. It is produced in state of the art manufacturing plant in a controlled environment resulting in consistent quality.

FIELDS OF APPLICATION

- Soil consolidation under foundations
- Dam curtain grouting, permeation grouting
- Consolidation of strata consisting of alluvium, fine sand & coarse silt where normal cement grouts cannot penetrate
- Grouting for subway excavation, river water canals, fine cracks, fissures in rock, RCC structures
- Strata consolidation during tunnel construction: injection grouting for pre-excavation (face grouting) and post-excavation
- Grouting of pointing or jointing mortars of masonry dams, heritage structures, etc.

ADVANTAGES

- Unique PSD results in enhanced N value. Effective penetration and filling of deep fine cracks, fissures & pore spaces imparts greater water tightness
- Can be injected with standard cement grouting equipment
- Extended workable time for ease of application and effective penetration in soil strata
- Compatible with most of the admixtures to accelerate / retard the setting time
- Non-toxic, environmentally friendly
- Cost effective, economical solution

TYPICAL PROPERTIES

At 27^0C under laboratory conditions

Property	Value
Form	Dry fine powder
Component	Single
Particle size d_{95}	< 11.5 microns
Fineness by Blaine	> 9000 cm^2/gm
Marsh Cone Viscosity[1]	27 to 38 seconds

1: Orifice diameter 4.76 mm. Water to powder ratio 1. Dosage of super plasticiser dosage: 1% to 2%. Results may vary as per site conditions

MIXING

Always add powder in to water. Add complete bag in the pre measured water. Small quantities up to 25 kg can be mixed with hand held assembly of drill machine and mixing paddle with 400 to 1200 rpm. Larger quantities shall be mixed with high speed colloidal shear vane mixers of 1400 rpm. If required, adjust the fluidity and setting time with the help of chemical admixtures. Typical mixing time is 5 to 10 minutes. Mix until a smooth, lump free fluid grout is obtained. Transfer the mixed material in agitator

*Formerly known as Alccofine 1101S

container. Mixed material shall be injected within 45 minutes after mixing.

PRECAUTIONS

Make sure to agitate mixed grout slurry in the container continuously. Avoid leaving mixed grout unattended. Make sure that adequate quantity of grout is available for continuous injection process. For better flow and flow retention properties; temperature of mixing water should be less than 20^0C. Clean all the tools and equipment immediately after use with ample amount of water.

TECHNICAL SERVICE

Consult Alccofine technical service department for the information related to the product and its application.

PACKAGING

Alccofine 1109SS is available in 25 Kg bags. Other pack sizes are available on request

STORAGE AND SHELF LIFE

Bags of Alccofine 1109SS should be stored in well-ventilated, sheltered, cool, dry area and protected from moisture, rain and heat. Under such storage conditions shelf life of sealed product is minimum six months from the date of manufacture.

NOTE

If required, Alccofine 1109SS can be supplied pre mixed with compatible super-plasticiser.

HEALTH and SAFETY

PPE: Hand gloves, goggles and suitable respiratory mask shall be used.
PRECAUTIONS: Avoid prolonged contact with skin. Like for all other micro fine materials, may cause irritation to eyes and respiratory system if inhaled. If swallowed seek medical attention immediately.
HAZARD: Regarded as non-hazardous for transportation.
DISPOSAL: Empty bags shall not be reused and disposed off as per local rules and regulations.
ADDITIONAL INFORMATION: Refer MSDS of the product.

DECLARATION
All the information is based on facts and figures experienced in the field and laboratory. It is the responsibility of the end user to reconfirm the performance parameters. As company does not have any control on handling of the product and site situation, it cannot be held responsible for deviation in the performance parameters mentioned in this product data sheet.

JAS-ANZ
M50007121D

CORPORATE OFFICE:
Counto Microfine Products Pvt. Ltd.
Velho Building, Opp. Municipal Garden,
Panaji, Goa, 403001 (INDIA)

MARKETING OFFICE:
Ambuja Cements Limited
Elegant Business Park,
Andheri (E), Mumbai 400059

CONTACT:
alccofine.customercare@ambujacement.com
www.alccofine.com
+91 9920085526

A Joint Venture of Ambuja Cements Ltd and Alcon Goa

SUMMARY OF TEST

Client : Sinohydro Corporation Ltd. (B-11)
Project : Upper Tamakoshi Hydroelectric Project

A. Physical Test

S.N.	Description of Cement	Sedimen-tation Test (% by Vol.)	Marsh Cone Viscosity Test (sec.)	# 200 Sieve Retained Value (% by wt)	Compressive Strength of Grout N/mm^2			Remarks
					3 days	7 days	28 days	
1	Ambuja Mirco Fine Cement	1.01	45	0.34	40.5	48.0	57.3	

B. Chemical Test

S.N.	Description of Cement	Loss on Ignition %	Silica %	Na_2O %	K_2O %	Lime Saturation Factor	Insolube Residue %	Ratio Al_2O_3/Fe_2O_3 Min.	MgO %	Alkali Content %	SO_3 %	Remarks
1	Ambuja Mirco Fine Cement	2.10	20.90	0.45	0.24	0.65	2.40	4.70	2.60	0.60	2.70	

S.N.	DESCRIPTION / SOURCE	Loss on Ingnition	Moisture	Silica	Fe_2O_3	Al_2O_3	SO_3	Retain on 45 µm	Specific Gravity	Strength Activity Index with Portland Cement (%)		Remarks
		%	%	%	%	%	%	% by wt.	(g/cc)	7 days	28 days	
1	Flyash (NTCC) India	0.8	0.03	59.9	2.9	35.4	1.90	18	2.325	72.5	93.9	

S.N.	DESCRIPTION / SOURCE	Loss on Ingnition	Moisture	Silica	Strength Activity Index with Portland Cement (%)		Remarks
		%	%	%	7 days	28 days	
1	Silica Fume (Shakti)	4.5	0.01	79	83.5	107	

S.N.	DESCRIPTION / SOURCE	Chloride	Water Content	Remarks
		%	%	
1	Admixture Sika 1016 NS	0.02	59.9	
2	Admixture Sika 2004 NS	0.001	52.47	

AKARA MATERIALS TESTING LABORATORY PVT. LTD.
Tinkune, Kathmandu, Nepal
Tel: 5104464,5104487
Email: akaramaterials08@gmail.com

Sedimentation Test for Cement Grout Mixture after 2 Hours
Related to ASTM C 939

Client : Sinohydro Corporation Limited. **Date:** 26/07/18
Project : Upper Tamakoshi Hydro-electric Project Temp: 27º C
Location
Material Description : a) Ambuja Micro Fine Cement
b) W/C Ratio 0.46%

S.No.	Description	Unit	Trial 1	Trial 2	Trial 3
1	Initial Reading of Cement Grout Mixture	mL	500	500	500
2	Final Reading after 2 Hrs. of cement Grout	mL	495	495	495
3	Sedimentation Rate of Net Grout Mix after 2 hrs. (% by Volume)		1.01	1.01	1.01
4	Average Value		1.01		

Comments:

Tested By:

Checked By:

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Tinkune, Kathmandu, Nepal
Tel: 5104464,5104487
Email: akaramaterials08@gmail.com

MARSH CONE VISCOSITY TEST (FLOW CONE METHOD)
ASTM C- 939

Client	: Sinohydro Corporation Limited.	**Date:**	26/07/18
Project	: Upper Tamakoshi Hydro-electric Project	**Time:**	
Location		***Room Temp ° C***	: 27
Material Description	:	***Water Temp ° C***	: 27
Cement	: Ambuja Micro Fine Cement	***Grout Temp ° C***	: 28
W/C Ratio	: 0.46 (Defined as per Efflux Test)	**Mix No :**	1

A *CALIBRATION OF APPARTUS*

S.No.	Description	Unit	Trial 1	Trial 2
1	Volume of Water	mL	1730	1725
2	Start time of Discharge		12 09:10	12:09:39
3	Final Time of Discharge		12:09:18:1	12:09:47
4	Net time of Efflux of water	Sec.	8.1	8
5	Average time of Effluxing of Water	Sec.	8.1	

Specification Time (0.80±0.2 Sec.)

B *Flow of Grout*

S.No.	Description	Unit	Trial 1	Trial 2
1	Weight of Cement in Mix	Kg	2.6	2.5
2	Weight of Sand in Mix	Kg	-	-
3	Weight of Admixture in Mix	Kg	-	-
4	Weight of Water in Mix	Kg	1.15	1.15
5	Start Time of Discharge		-	-
6	Final Time of Discharge		-	-
7	Net time of Efflux of Grout	Sec.	46	44
8	Average time of Efflux	Sec.	45.0	
9	Specified Efflux Time	Sec.	36~50	
10	W/C Ratio Defined at Specified Efflux Test	%	0.46	

Comments:
The time of efflux of a specified volume of grout from a flow cone is measured - 45 sec (Specfied 36~50 sec) and the w/c ratio is defined - 46 % accordingly.

Tested By:

Checked By: 24/8/18

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Tinkune, Kathmandu, Nepal
Tel: 5104464,5104487
Email: akaramaterials08@gmail.com

200 SIEVE RETAINED VALUE
Related to ASTM C 939

Client : Sinohydro Corporation Limited. **Date:** 26/07/18
Project : Upper Tamakoshi Hydro-electric Project
Location
Material Description : Ambuja Micro Fine Cement

S.No.	Description	Unit	1	2	3
1	Wt of Material before washing	gm	92.64	95.92	96.78
2	Wt. of Material retained after wash	gm	0.22	0.32	0.44
3	% Retained Value # 200 sieve	%	0.24	0.33	0.45
4	Average % Retained Value # 200 sieve by wt.	%	0.34		

Comments:

Tested By:

Checked By:

AKARA MATERIALS TESTING LABORATORY PVT. LTD.
Tinkune, Kathmandu, Nepal
Tel: 5104464,5104487
Email: akaramaterials08@gmail.com

GROUT TEST (Related to ASTM C-939)

Client : Sinohydro Corporation Limited.
Project : Upper Tamakoshi Hydro-electric Project
Location
Source of Material (a) Ambuja Micro Fine Cemet (India)
(b) Admixture -
© W/C Ratio : 0.46

Date: 26/07/2018
Room Temp: 27
Water Temp: 27
Grout Temp: 25
Mix No. : 1

Setting time of Cement Grout

Cement taken, gm =
Amount of water, ml =

SN	Time	Elapsed Time (hr: min)	Penetration from bottom (mm)	Remarks
1				
2				
3				Initial Setting
4			No impression	Final Setting

Initial setting time :
Final setting time : No impression

Compressive Strength Test :

Water Cement Ratio = 0.46
Weight of Cement : 2.50 Kg
Weight of Water : 0.950 Kg
W/C Ratio : 0.46

Cube Mould(50 x 50 mm)
Length, mm = 50
Width, mm = 50

Date of Casting		29/07/18		29/07/18			29/07/18		
Date of Testing		01/08/18		05/08/18			26/08/18		
	Compresssive Strength at 3 days			Compresssive Strength at 24 days			Compresssive Strength at 24 days		
Sample No.	Weight gm	Breaking load,KN	Comp. S, N/mm2	Weight gm	Breaking load,KN	Comp. S, N/mm2	Weight gm	Breaking load,KN	Comp. S, N/mm2
1	232	104	41.6	236.0	120.0	48.0	244.0	154.0	61.6
2	235	100	40.0	239.0	116.0	46.4	244.0	144.0	57.6
3	234	100	40.0	235.0	124.0	49.6	249.0	132.0	52.8
	Average, N/mm^2		40.5	Average, N/mm^2		48.0	Average, N/mm^2		57.3

Comments:

The time of efflux of a specified volume of grout from a flow cone is measeured - 45 sec. (Specified 36 ~50 sec) and the w/c ratio is defined - 46 % accordingly. 9 cubes mold cast at same w/c ratio using for 3,7 & 28 days comp. str. Test. Specimen has not achieved proper setting time even after 24 hours demoulding time.

Tested By:

Checked By:

AKARA MATERIALS TESTING LABORATORY PVT. LTD.
Tinkune Subidhanagar, Kathmandu, Nepal
Tel: 5104454, 5104487
Email : akaramaterials08@gmail.com

CHEMICAL TEST ON CEMENT

Method Used (IS:4032-1968)

Client : Sinohydro Corporation Limited.
Project : Upper Tamakoshi Hydro-electric Project
Location :
Source of Material : Ambuja Micro Fine Cement (India)

Date: 06/08/18

S.No.	Test Parameters %	Sample Name	Requirements of IS:8112-2013	Remarks
		Ambuja Micro Fine		
1	Loss on Ignition % Max.	2.1	-	
2	Insoluble Residue %	2.4	4 Max	
3	Silica %	20.9	-	
4	Na_2O %	0.45	-	
5	K_2O %	0.24	-	
6	Lime Saturation Factor	0.65	-	
7	Ratio Al_2O_3/Fe_2O_3 Min.	4.7	0.66 Min	
8	MgO %	2.6	6 Max	
9	Total Alkali Content %	0.6	0.05 (for Prestressed Structures)	
10	SO_3%	2.7	3.5 Max	

Comments :

Tested By:

Checked By:

SUMMARY OF CEMENT TEST

: Sinohydro Corporation Pvt. Ltd. (B-11)

Date : 25/12/2017

Physical Test

Description of Cement	Consistency & Setting Time			Strength N/mm²			Fineness sp. Surface m²/kg	Soundness (mm)	Remarks
	Norm. Const.(%)	Initial (min.)	Final (min.)	3 days	7 days	28 days			
Gold OPC 53 Grade (Manuf. Week No. 39, 2017)	29.50	173 min	240 min	27.3	32.3	51.1	366	3.5	

Chemical Test

Description of Cement	Loss on Ignition %	Silica %	Na_2O %	K_2O %	Lime Saturation Factor	Insolube Residue %	Ratio Al_2O_3/Fe_2O_3 Min.	MgO%	Alkali Content %	SO_3 %	Remarks
Gold OPC 53 Grade (Manuf. Week No. 39, 2017)	2.00	20.60	0.30	0.70	0.90	1.00	1.00	0.80	0.76	2.90	

Alpha Material Testing Laboratory (P) Ltd. * Kammasandra *

Soil Test (P.) Limited
ENVIRONMENTAL ASSESSMENT & MATERIAL TESTING DIVISION

Battishputali.
Kathmandu,Nepal

Phone : 977-1-4470551
Fax : 977-1-4470551
Email : soiltest@wlink.com.np

ANALYSIS REPORT

Client Name :	Akara Lab	Packaging :	polyethylene Bag
Sample :	Cement	Description :	Dust
Entry No :	8-074/10	Sample By:	Client
Received date :	10-8-074	Lab Code:	C64
Reporting date :	5-09-074		
Determination :	Chemical Analysis		

S.No.		Observed Values	
	Lab sample code	C 30	Requirements of IS: 8112-2013
	Label on the sample	Rassigold 53 grade	
	parameters		
1	Loss on Ignition %	2	5%
2	Silica %	20.6	-
3	Na_2O%	0.3	-
4	K_2O %	0.7	-
5	Lime Saturation Factor	0.9	
6	Insoluble Residue %	1	4 Max
7	Ratio Al_2O_3/Fe_2O_3	1	0.66 Min
8	MgO %	0.8	6 Max
9	Total Alkali content %	0.76	0.05 (for prestressed structures)
10	SO_3%	2.9	3.5 Max

Note: 1) Results are valid only for submitted samples.
2) Samples, such as water and food, will be destroyed after 7 days, other samples will securely be stored for a month only.

Analyzed By

SOIL TEST (P) LTD. KATHMANDU

Authorised Signature
Saraswati Vaidya

AKARA MATERIALS TESTING LABORATORY PVT. LTD.

Tinkune, Subidhanagar, Kathmandu, Nepal
Tel: 5104464, 5104487
Email : akaramaterials08@gmail.com

ANALYSIS REPORT

Client : Sinohydro Corporation Pvt. Ltd. **Date : 20/12/2017**
Project : Upper Tamakoshi Hydroelectric Project B-11
Location :
Material Description : Raasi Gold OPC 53 Grade
(Manufacture Date Week 39, 2017)

S.No.	Parameters	Sample Name	Requirements of IS : 8112-2013
		Raasi Gold OPC 53 Grade	
1	Loss on Ignition % Max	2.00	5%
2	Silica %	20.60	-
3	Na_2O, %	0.30	-
4	K_2O%	0.70	-
5	Lime Saturation Factor	0.90	-
6	Insolube Residue % Max	1.00	4 Max
7	Ratio Al_2O_3/Fe_2O_3 Min.	1.00	0.66 Min
8	MgO % Max.	0.80	6 Max
9	Alkali Content %	0.760	0.05 (prestressed)
10	SO_3 % Max.	2.90	3.5 Max

Notes:

1 Results are valid for submitted samples.

Comments :

Tested By:

Checked By:

AKARA MATERIALS TESTING LABORATORY PVT. LTD.
Tinkune, Subidhanagar, Kathmandu, Nepal
Tel: 5104464, 5104487
Email : akaramaterials08@gmail.com

CEMENT TEST (AS PER IS 4031 :1968)

Client : Sinohydro Corporation Pvt. Ltd.
Project : Upper Tamakoshi Hydroelectric Project B-11
Location :
Source of Material : Raasi Gold OPC 53 Grade
(Manufacture Date Week 39, 2017)

Date: 20/11/2017

Room Temp: 26 ° C
Water Temp: 24 ° C
Curing Temp: 24 ° C

Normal Consistancy of cement :

Cement Taken = 400 gm

SN	Amount of Water ml	Water Added %	Penetration from bottom (mm)
1	116	29.0	10
2	118	29.5	6
3			
4			

N. Consistency at (5 ~ 7 mm Peneration) P = 29.5%

Setting time of Cement

Cement taken, gm = 400
Amount of water,ml = (85% of NC) 100.3
Flow =

SN	Time	Elapsed Time (hr: min)	Penetration from bottom (mm)	Remarks
1	11:25	0:00	0	Start Time
2	13:23	1:58	5	Initial Setting
3	14:25	3:00	2	Final Setting

Initial setting time :	1:58	173 min		> 45 min
Final setting time :	3:00	240 min	No impression	< 375 min

Compressive Strength Test :

Mortar Ratio = 1:3
Weight of Cement, gm 1800
Weight of Sand, gm 5400
Water added, ml = (P/4 + 3) x (total wt. of Cement + Sand)/100 747

Cube Mould (70.7 x 70.7 mm)
Length, mm = 70.7
Width, mm = 70.7

Date of Casting		20/11/2017		20/11/2017			20/11/2017		
Date of Testing		23/11/2017		27/11/2017			17/12/2017		
Sample No.	Compresssive Strength at 3 days			Compresssive Strength at 7 days			Compresssive Strength at 28 days		
	Weight gm	Breaking load,KN	Comp. S, N/mm2	Weight gm	Breaking load,KN	Comp. S, N/mm2	Weight gm	Breaking load,KN	Comp. S, N/mm2
1	825	130	26.0	822	160	32.0	827	250	50.0
2	828	140	28.0	863	164	32.8	853	256	51.2
3	813	140	28.0	826	160	32.0	844	260	52.0
	Average, N/mm^2		27.3	Average, N/mm^2		32.3	Average, N/mm^2		51.1

Comments:

1. Standard Sand Conformining to IS 600 i.e Grade I, II & III (33.3% each)

Tested By:

Checked By:

9i

AKARA MATERIALS TESTING LABORATORY PVT. LTD.
Tinkune, Subidhanagar, Kathmandu, Nepal
Tel: 5104464, 5104487
Email : akaramaterials08@gmail.com

FINENESS OF CEMENT BY AIR PERMEABILITY APPARTUS (BLAINE)
AS PER IS 4031 : 1968

Client : Sinohydro Corporation Pvt. Ltd. **Date : 26/11/2017**
Project : Upper Tamakoshi Hydroelectric Project B-11
Location :
Material Description : Raasi Gold OPC 53 Grade
(Manufacture Date Week 39, 2017)

A. CALCULATION TO FINE VOLUME OF CELL			Unit			
1	Wt of Cell+2 No. Filter Paper, gm	(a)	gm	100.822		100.8220
2	Wt of Cell+2 No. Filter Paper+Mercury, gm	(b)	gm	185.482		185.299
3	Temperature of the Mercury,		°C	20.0		20.0
4	Density of Mercury at Tested Temp^r,	(c)	gm/cm^3	13.550		13.550
5	Volume of Cell, ml	V_1= (b-a)/c	ml	6.248		6.234
			Average	6.241		
B. BULK VOLUME OF COMPACTED BED OF CEMENT						
6	Wt. of Beaker, gm	(a)	gm	19.572		19.572
7	Wt. of Beaker + Mercury Filled over Cement Bed, gm	(b)	gm	78.467		78.520
8	Temperature of the Mercury, °C		°C	20.0		20.0
9	Density of Mercury at Tested Temp^r, gm/cm^3	(c)	gm/cm^3	13.550		13.550
10	Volume of Cell over the Compacted Cement, ml	V_2= (b-a)/c	ml	4.346		4.350
11	Average Volume of Compacted Bed of Cement, gm	V_2	gm	4.348		
12	Volume of Compacted Bed of Cement, gm	V_c= V_1 - V_2	gm	1.893		
C. CALIBRATION FROM STANDARD CEMENT						
12	Density of Standard Cement, gm/cm^3	(γ)	gm/cm3	3.150		
13	Desired Porosity of Cement (ε)	(p)		0.500		
14	Wt. of Standard Cement, gm	W=V_c*ρ(1-p)	gm	2.981		
15	Specific Surface of Standard Cement, m^2/kg	(S_s)	m2/kg	381.300		
16	Temperature of Test, °C		°C	20.0		
17	Viscosity of Air at Tested Temp^r, Pa.s	(n)		0.0000181		
	FALLING TIME ON MANOMETER DROP					
18	Time to fall from B to C Position, sec		sec	258	260	261
19	Average Time to fall from B to C Position, sec	(Ts)	sec	259.7		
20	Constant K	K=(1.412*Ss*√n)/√Ts		0.142		
D. SPECIFIC SURFACE AREA OF CEMENT						
21	Temperature of Test, °C		°C	20.0		
22	Viscosity of Air at Tested Temp^r, Pa.s	(n)		0.0000181		
	FALLING TIME ON MANOMETER DROP					
23	Time to fall from B to C Position, sec			229	225	227
24	Average Time to fall from B to C Position, sec	T		227.0		
25	Specific Sruface Area of Cement, m^2/kg	S=(0.708*K*√T)/√n		356		

RESULT: The Fineness of the Tested Cement is 356 > 225m2/kg.

Tested By:

Checked By :

Construction

Product Data Sheet
Edition 01/01/2014
Identification no:
02 03 01 01 002 0 000004
Intraplast® EP

Intraplast® EP

Expanding grout admixture

Product Description	Intraplast® EP is an expanding grout admixture for pressure/injection grouting. By introducing into the concrete mix, wet volume expansion and increased fluidity without segregation are produced.
Uses	Intraplast® EP is used to increase flow and cohesion in cement grouts (addition of sand is possible) and to develop non-shrink property. This product can be used for grouting of: ■ Pre-stressed cable ducts ■ Rock and soil anchoring ■ Bearing plates ■ Pre-placed aggregates ■ Tunnel linings
Characteristics / Advantages	Intraplast® EP provides the following beneficial properties: ■ Improved fluidity ■ Increased cohesion ■ Volume expansion in the wet state to develop non-shrink property ■ Chloride free - does not attack reinforcement or prestressed cables
Dispensing	Add directly to the cement / water mix in the mixer. Sand may be added as required.

Product Data

Form

Appearance / Colour	Brown powder
Packaging	12.5 kg bag

Storage

Storage Conditions / Shelf-Life	12 months from date of production if stored properly in dry conditions in undamaged and unopened original sealed packaging. But after opening, it should be consumed within one month & should be packed properly after use.

Technical Data

Chemical Base	Modified naphthalene	
Bulk Density	~0.85 kg/l at 27°C	
Fluidity	~ 20 sec.	(According to ASTM C 939 -87)

Construction

Mechanical / Physical Properties		
Expansion	3-9 %	(According to ASTM C 937- 80)

System Information

Application Details	
Dosage	1% by weight of cement (500 gm per 50 kg bag of cement).
Application Method / Tools	Add directly to the cement / water mix in the mixer. Sand may be added as required.
Cleaning of Tools	Clean all tools and application equipment with water immediately after use. Hardened/cured material can only be mechanically removed.
Value Base	All technical data stated in this Product Data Sheet are based on laboratory tests. Actual measured data may vary due to circumstances beyond our control.
Health and Safety Information	For information and advice on the safe handling, storage and disposal of chemical products, users shall refer to the most recent Material Safety Data Sheet containing physical, ecological, toxicological and other safety-related data.
Legal Notes	The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions in accordance with Sika's recommendations. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The user of the product must test the product's suitability for the intended application and purpose. Sika reserves the right to change the properties of its products. The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users must always refer to the most recent issue of the local Product Data Sheet for the product concerned, copies of which will be supplied on request.

Sika India Pvt. Ltd.
Commercial Complex II
620, Diamond Harbour Road
Kolkata, 700 034, India

Phone +91 33 2447 2448/2449
Telefax +91 33 2396 8688
ind.sika.com
info.india@in.sika.com

Formats

UPPER TAMAKOSHI HYDRO ELECTRIC PROJECT

Sinohydro Corporation Ltd

Grouting Record

Location		Prepared by		Shift		Page		Date of Grouting		Leading Grouter	

Hole Number (Nr)	Hole Length (m)	Permeability (Lugeon)	Type of Grout	Mix 1		Mix 2		Mix 3		Mix 4		Packer Setting Depth (m)	Inter-connected Holes (Nr)	Mix Volume (litre)	Injection Volume (liter)	Pressure (bar)	Remarks
				w/c ratio	Cement (Kg)	w/c ratio	Cement (Kg)	w/c ratio	Cement (Kg)	w/c ratio	Cement (Kg)						
						—	—	—	—	—	—						Start time:
				—	—			—	—	—	—						End time:
				—	—	—	—			—	—						Stopping Criteria:
				—	—	—	—	—	—								Chinage:
						—	—	—	—	—	—						Start time:
				—	—			—	—	—	—						End time:
				—	—	—	—			—	—						Stopping Criteria:
				—	—	—	—	—	—								Chainage:
						—	—	—	—	—	—						Start time:
				—	—			—	—	—	—						End time:
				—	—	—	—			—	—						Stopping Criteria:
				—	—	—	—	—	—								Chainage:
						—	—	—	—	—	—						Start time:
				—	—			—	—	—	—						End time:
				—	—	—	—			—	—						Stopping Criteria:
				—	—	—	—	—	—								Chainage:

Total Cement Used (kg)	Total Mortar Used (kg)	Total Mix Volume (ltr)	Total Injected Volume

Mix Number	Cement Type	w/c Ratio	Super- plasticizer (%)	Stabiliser (%)	Sand (%)	Accelerator (%)	Viscosity (sec)	Grout Density (g/cc)	Bleeding (%) at 1 hour	Initial Setting Time (min)	Final Setting Time (min)	Grout Temperature (°C)
1	OPC / MFC		—									
2	OPC / MFC		—									
3	OPC / MFC		—									
4	OPC / MFC		—									

Site observation

For The Contractor	For The Engineer
Name	Name
Signature	Signature
Date	Date

Upper Tamakoshi Hydroelectric Project

Sinohydro Corporation Ltd.

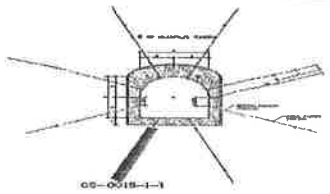
Data for Lugeon Test

Location: HT1 Chainage: 0+015 Hole No.: GS-0015-1-1 Hole diameter (mm): 76.00 Total depth (m): 12.00	Coordinate X: 422535.49 Y: 3089465.26 Z: 1974.65 Orientation (°): 206 Inclination (°): 67.5 Downward	Depth to groundwater (m): Top of test location (m): 2.00 Bottom of test location (m): 6.00 Test section (m): 4.00 Elevation of pressure gauge:

Test conducted on: 27 Dec, 2018 Test conducted by: Yang Hao Result interpreted by: Shadananda Gautam

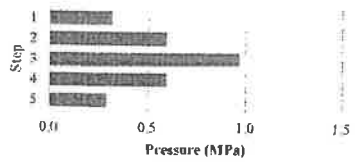
		Data Entry											
Test Step	1	Time (hh:mm)	10:58	10:59	11:00	11:01	11:02	11:03					
		Gauge Pressure (Mpa)	0.33	0.33	0.31	0.30	0.30	0.30					
		Flow Reading (ltr/min)	16.0	15.1	14.4	14.3	14.1	14.0					
	2	Time (hh:mm)	11:08	11:09	11:10	11:11							
		Gauge Pressure (Mpa)	0.59	0.60	0.60	0.58							
		Flow Reading (ltr/min)	32.3	32.2	31.8	31.6							
	3	Time (hh:mm)	11:14	11:15	11:16	11:17							
		Gauge Pressure (Mpa)	0.94	0.97	0.99	0.97							
		Flow Reading (ltr/min)	57.3	59.5	60.5	60.1							
	4	Time (hh:mm)	11:20	11:21	11:22								
		Gauge Pressure (Mpa)	0.58	0.61	0.59								
		Flow Reading (ltr/min)	39.7	39.6	40.1								
	5	Time (hh:mm)	11:25	11:26	11:27	11:28	11:29						
		Gauge Pressure (Mpa)	0.29	0.28	0.29	0.28	0.28						
		Flow Reading (ltr/min)	25.2	25.3	25.1	25.1	25.0						

Test Step	Time (hh:mm)		Water Pressure (Mpa)			Average flow (ltr/min)	Flow loss (ltr/min/m)	Respective Lugeon value
	From	To	Gauge Reading	Static	Effective			
1	10:58	11:03	0.31	0.00	0.31	14.65	3.66	11.75
2	11:08	11:11	0.59	0.00	0.59	31.98	7.99	13.49
3	11:14	11:17	0.97	0.00	0.97	59.35	14.84	15.34
4	11:20	11:22	0.59	0.00	0.59	39.80	9.95	16.77
5	11:25	11:29	0.28	0.00	0.28	25.14	6.29	22.13

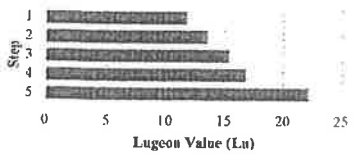


Location Map

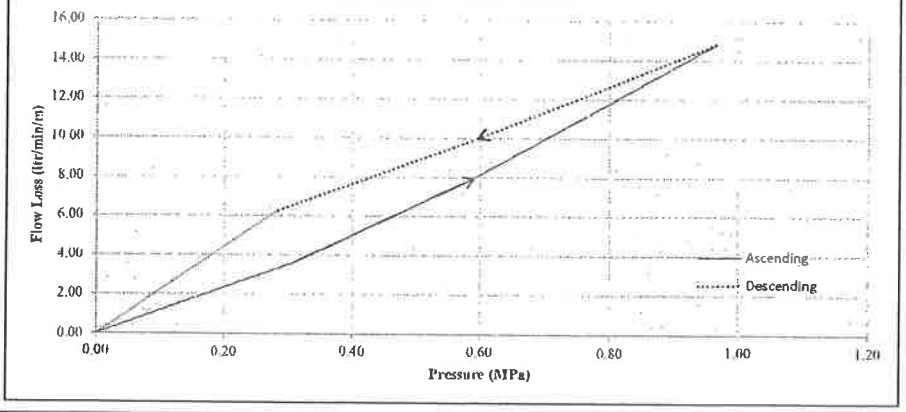
Water Pressure



Lugeon Pattern



Flow Loss vs. Pressure Pattern



Behaviour	Laminar Flow	Turbulent Flow	Dilation	Wash-out	Void Filling
Lugeon Pattern					
Flow Loss vs. Pressure Pattern					

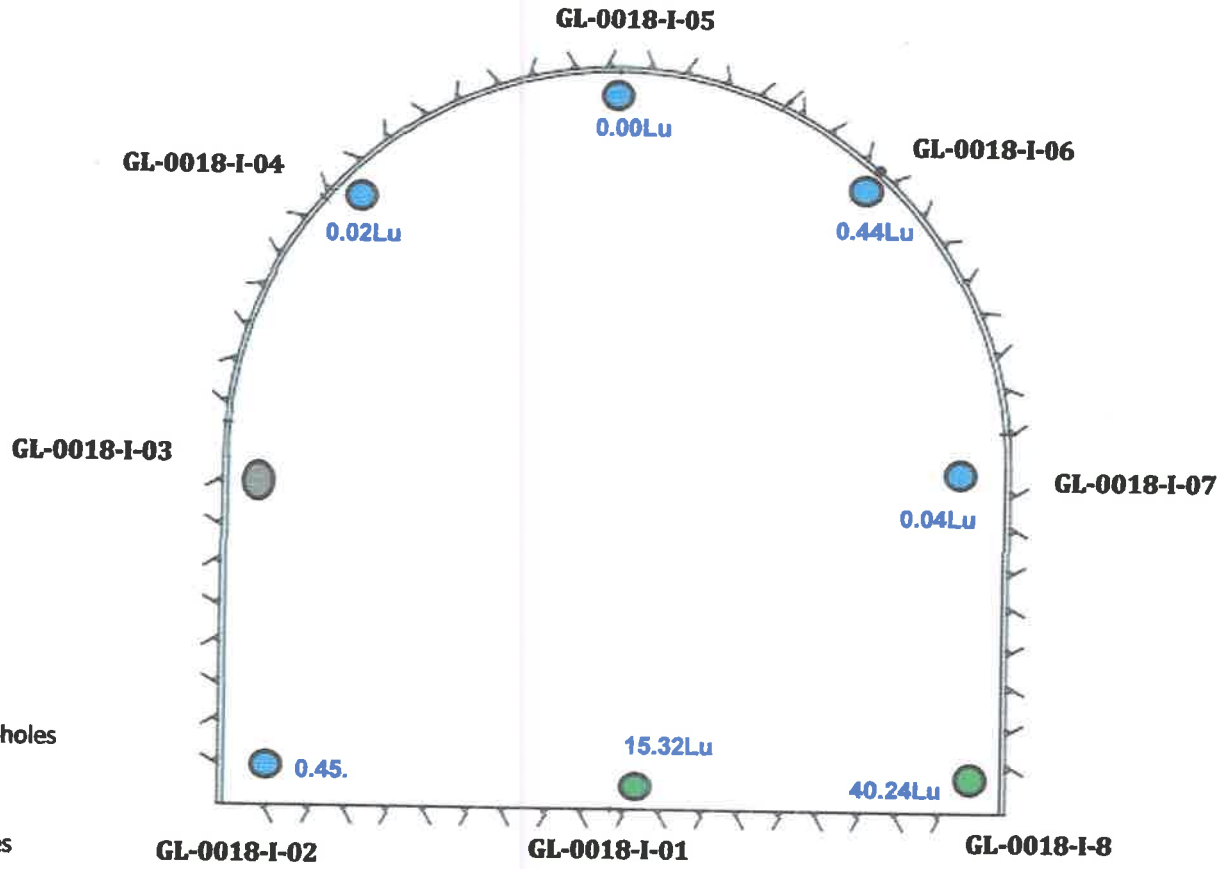
Interpretation (based on Quiñones-Rozo, 2010)	
Flow Type:	Wash-Out
Lugeon Value (Lu):	22.13
Hydraulic Conductivity (cm/sec):	2.9 E-04
Classification:	Medium
Condition of rock mass discontinuities:	Some Open

Engineer's Comments:

For the Contractor	For the Engineer
Name: Shadanda Gautam	Name:
Signature:	Signature:
Date: 27 Dec, 2018	Date:

Upper Tamakoshi Hydro Electric Project
Headrace Tunnel
Summary of Lugeon Test
HT1- Station 01 (Ch 0+018)

Date:
Shift:



Legend

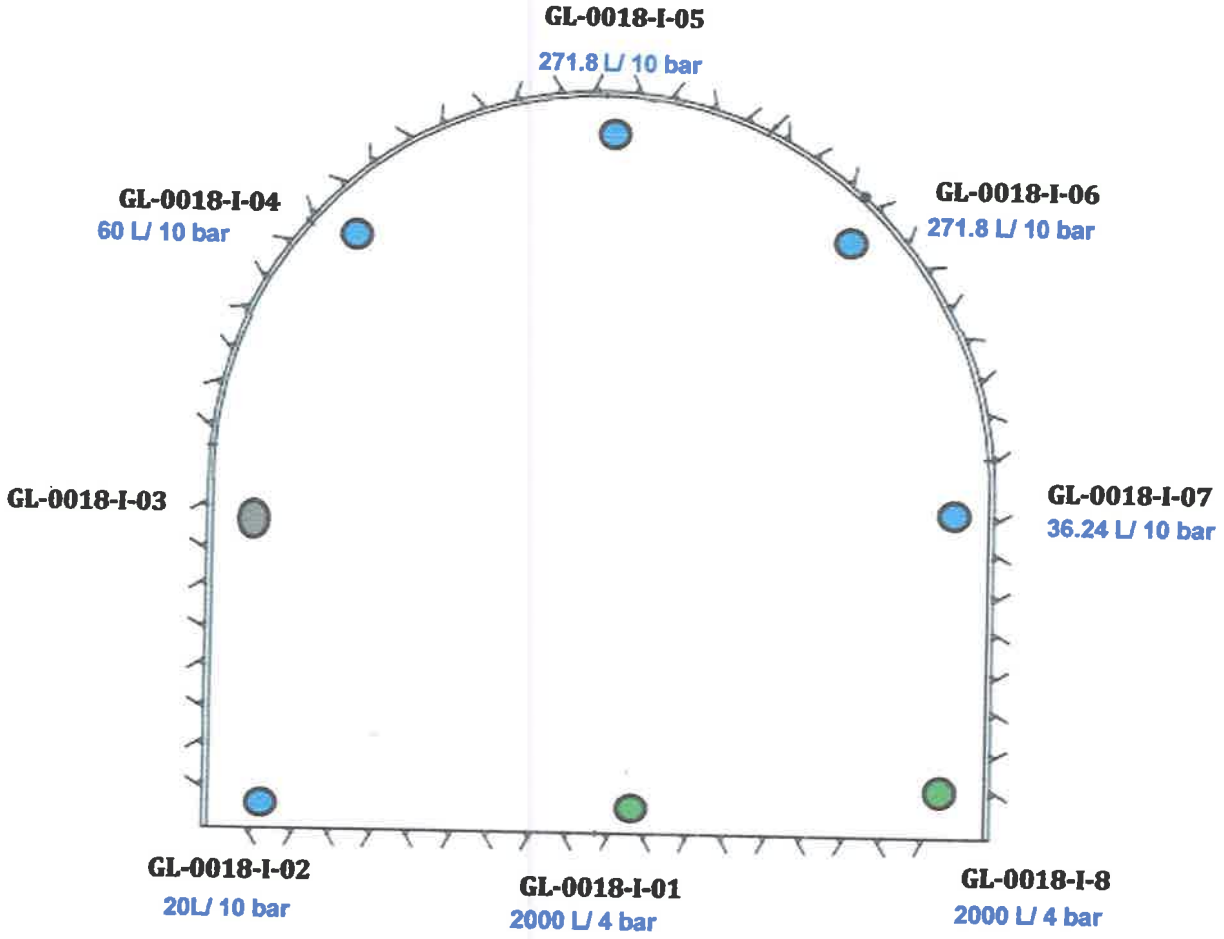
- 1st Round Grout Holes
- 2nd Round Grout Holes
- 3rd Round Grout Holes
- 4th Round Grout Holes
- 2 times Repeated Grout holes
- Completed Drill Holes
- MFC Finished Grout Holes
- OPC Finished Grout Holes

15.32 **Water Permeability (Lugeon)**

Barrier Grouting holes.
Packer Set at ....
Grout Section is ...

Upper Tamakoshi Hydro Electric Project
Headrace Tunnel
Grout Intake Record
HT1- Station 01 (Ch 0+018)

Date:
Shift:



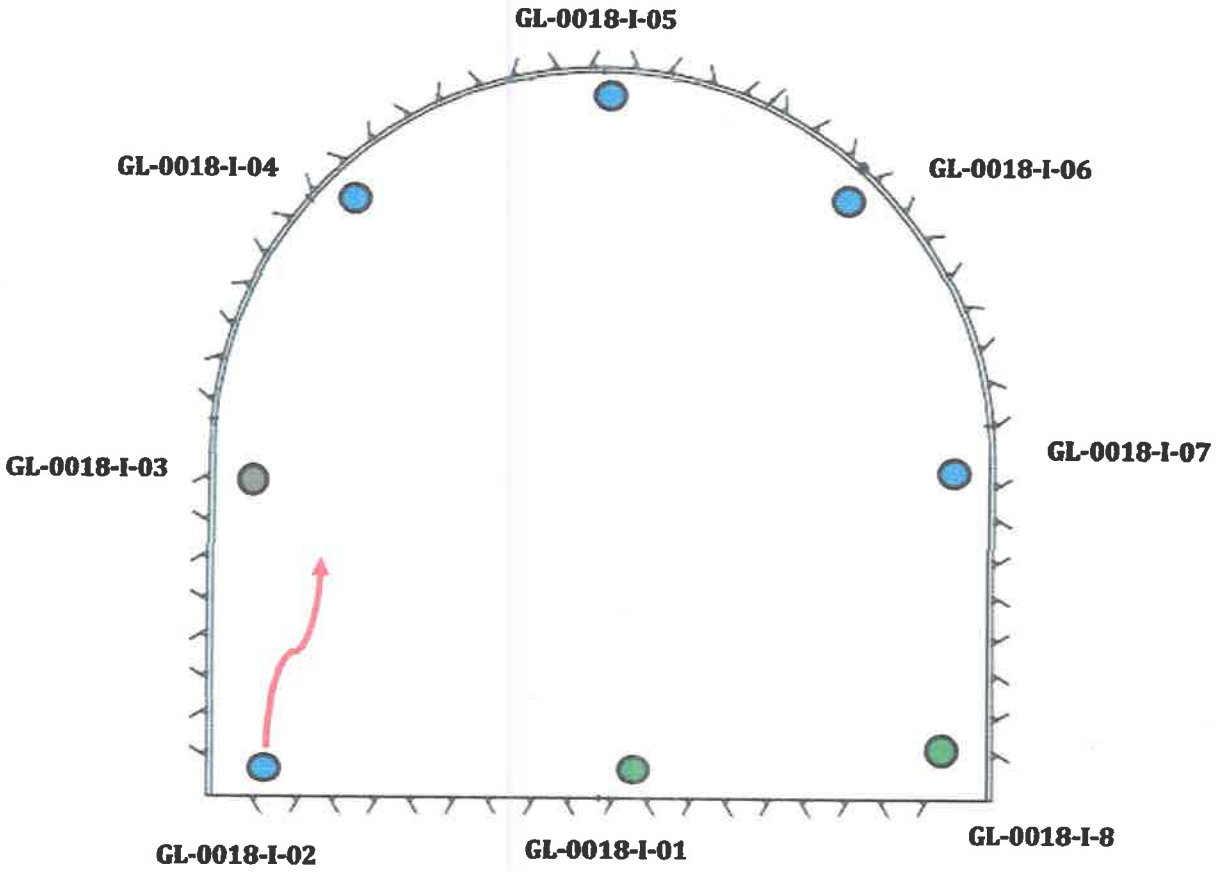
Legend

OPC Cement
2000 L / 1 bars
Stop. Vol. (L) / Press. (bars)

Barrier Grouting holes.
Packer Set at ....
Grout Section is ...

Upper Tamakoshi Hydro Electric Project
Headrace Tunnel
Grout Interconnection
HT1- Station 01 (Ch 0+018)

Date:
Shift:



Legend

Grout Travel Direction

Barrier Grouting holes.
Packer Set at ....
Grout Section is ...

Bio-Data

Zhang Baohong

Senior Engineer

EDUCATION

North China University of Water Resources and Electric （2008-2012）

Water resources and hydropower engineering. Undergraduate, bachelor.

Yellow River Conservancy Technical Institute (2001.09-2004.08)

Water resources and hydropower engineering. Junior college.

REGISTERED CERTIFICATE

Constructor Engineer (201703441034000003409094108170)

Blasting Engineer

WORK EXPERIENCE

November 2018—Present

Worked as a Chief Engineer in wind power project of Guang xi of Sinohydro, China.

October 2017— October 2018

Worked as a chief Engineer in irrigation project of Gansu China of Sinohydro.working content including tunnel excavating, grouting and concrete lining.

Jan. 2011—Mar. 2016

Worked as a Material Engineer for upper Tamakoshi Hydropower project of Nepal. Working content including material test, shotcrete quality control .grouting quality control of dam foundation etc.

June.2006—Dec. 2010

Worked as a material engineer for sikta irrigation project of Nepal. Working content including material test, quality control, grouting quality control of foundation of project.

Nov.2004—Mar. 2006

Worked as a quality control in-charge for sewage water treatment project of muscat. Oman of Sinohydro.working content including quality control.

Aug.2001—Sep. 2004

Worked as civil engineer for jingkang hydropower project of sinohydro si chuan china .working content including techincal instructor,situ quality checking etc.

Mr. Kunjjaan Popat Profile

A visionary, having an experience of over two decade in Infrastructure works like bridge repairs and strengthening, injection grouting

Valuing strong, long-term relationships over individual transactions helped him to promote and establish Trifix Infrastructure reputation for cutting edge client services.

His team has re-strengthened Heritage structures and buildings also and have also done addition and alteration works in prestigious Hospitals works such as Breach Candy Hospital, Tata Memorial Hospital and Jaslok Hospital in Mumbai.

MR. KUNJAN POPAT has been trained in Germany with German University in IRP (Injection, Repair, & Protection of Structures), in Singapore , Belgium ,Malaysia ,in Injections and in Switzerland for underground structures (injections , spray concrete, strengthening etc.)

It is his vision that is the driving force behind the growth of Triseal Technologies LLP.

A Qualified Civil Engineer by profession, he leads the Company in overall planning, general business, generating strategies and identifying opportunities.

Personal Information

NATIVE PLACE : MUMBAI INDIA
DATE OF BIRTH : 23RD JULY 1968
EXPERIENCE : 25 YEARS OF CIVIL AND INFRASTRUCTURE WORKS .
ATTACHED EXCEL FILE .
CONTACT DETAILS : email: kunjjaan@trifix.co.in , Mob: +91 9820044118

Education:

- **CIVIL ENGINEERING**
- **INTERIOR DESIGNING**
- **UNDERGROUND STRUCTURES (SWITZERLAND)**
- **INJECTIONS , REPAIRS AND PROTECTION OF CONCRETE STRUCTURES (IRP GERMANY)**
- **INJECTIONS AND WATERPROOFING (SWITZERLAND, BELGIUM , DUBAI , SINGAPORE , MAYSIA)**
- **POST GRADUATE BUSINESS ADMINISTRATION**

SOME OF THE INTERNATIONAL PROJECTS

S.No	NAME OF THE PROJECT	TYPE OF WORK	YEAR OF WORK
1	Strengthening and injection works in Nepal region	Composite , Fibers , Injection works , in Himalayan Bank and other works in Nepal region	2008-10
2	Soil Stabilzation work in Nepal	Stabilzation of soil during the excavation works and waterproofing of area for basements	2009
3	Tribhuvan International Airport Ground Maintenance work in Nepal	Cleaning , opening up of Joints and filling the joints of Parking Bay area	2009- 10
4	Retrofitting works in Nepal with Venus Construction & Water Proofing Pvt. Ltd.	Composite fibers, injection grouting in Kathmandu, Pokhara , Birganj and other areas with Venus Group of Companies.	2014-16
5	KUKL Water Supply Project Sundarijal Water Reservoir, Government of Nepal .	Waterproofing works with PU Injection	2018
6	Crystal Building Complex Republic of Congo Africa	Waterproofing works with PU Injection	2018

SOME OF THE CRITICAL HERITAGE JOBS DONE BY US

S.No	NAME OF THE PROJECT	TYPE OF WORK	YEAR OF WORK
1	**Structural Conservation of Nabha Temple and fort at Punjab**	Structural Repairs and Strengthening	**2001**
2	**Masonry Arch Bridges for Indian Railways 64 Nos**	Structural Repairs and Strengthening	**2001-04**
3	Structural Strengthening of Humayun Tomb With Helifix	Structural Repairs and Strengthening	2004
4	St Anthony's Church Chennai	Structural Repairs and Strengthening	2004
5	Zionshurch Chennai	Structural Repairs and Strengthening	2004
6	Veternary College Chennai	Structural Repairs and Strengthening	2005
7	High Court Chennai	Structural Repairs and Strengthening	2005
8	VanithaVishramSurat	Structural Repairs and Strengthening	2005
9	Repairs and Strengthening of the CONTRACTOR HOUSE at Ballard Pier Mumbai for Shapoorji Pallonji.	Structural Repairs and Strengthening and Basement Waterproofing	2007
10	External Stone Facade Treatment at TCS House Mumbai For ShapoorjiPallanji	Protective Coatings	2007
11	Structural Conservation of RamgarhiaBunga , Golden Temple Amritsar	Structural Repairs and Strengthening	2008-2009
12	Structural Conservation of Summer Palace of Maharaja Ranjitsingh Amritsar	Structural Repairs and Strengthening	2008-2009
13	Structural Conservation of Rambagh Gate Amritsar	Structural Repairs and Strengthening	2008-2009

SOME OF THE INJECTION WORKS DONE BY US

S.No	NAME OF THE PROJECT	TYPE OF WORK	YEAR OF WORK
1	Repairs and Strengthening of the CONTRACTOR HOUSE at Ballard Pier Mumbai for ShapoorjiPallonji.	Structural Repairs and Strengthening and Basement Waterproofing	2007
2	Waterproofing of Pipe line for Oil India	Waterproofing of Pipeline which is laid by Oil India from Assam to West Bengal passing under the river bed of 7 rivers using TBM machines.	2008- 09
3	Waterproofing of Basement for Ganaraja Builders Dombivili	Waterproofing of Basement	2009
4	Waterproofing of Construction Joints for E- Space PUNE	Waterproofing and filling up of construction joints with Acrylate gels	2008
5	Soil stabilsation work for Reliance Energy	Stabilsation of Soil and Rock structure for Reliance Energy Tower at Kandivili	2009
6	Injection Grouting	Nagarjunaconstructions ,Ahluwalia Group , Reliance Energy	2009
7	Waterproofing of Construction Joints for Magarpatta City PUNE	Waterproofing of cracks with Injection grouting system	2012-14
8	Waterproofing works for Hiranandani group	Waterproofing of Podium level	2015
9	Waterproofing works and strengthening work for Ruparel Realty Mumbai	Waterproofing of Podium Basement / and bathroom areas for 6 Towers	2015-6
10	Kesar Harmony	Podium waterproofing PU Injections	2018-19
11	Golden Galaxy Khargar	Podium waterproofing PU Injections	2018-19
12	Sai Siddhi Society Khargar	Podium waterproofing PU Injections	2018-19
13	TCG House BKC	Terrace and Podium Waterproofing	2018-19
14	Smart House Juhu	Terrace and Podium Waterproofing	2018-19
15	Soil Stabilisation Works Ocean Towers D B Realty/ Pancshil	Soil Stabilisation	2018-19
16	ITD Metro	Soil Stabilisation	2018-19
17	Crystal Building Complex Republic of Congo Africa	Waterproofing works with P U Injection	2018-19

Name : Shadananda Gautam
Address : Rukum, Musikot
Email : sharmashada@gmail.com
Phone : 9849774370

Education

• **Master in Hydraulic and Hydropower Engineering:**
Tianjin University, China (2016 Sep-2018June): "Construction Optimization of Earth Rock Dam"

• **Bachelor in Civil Engineering:**
Tribhuvan University, Pulchowk Engineering Campus (2010 Sep-2015 Dec)

Work Experience

• Asist. Lecture in Advance College of Engineering and Management (Hydropower Engineering) (2016Jan-2016 Aug)

• Working as a Technical Department Coordinator in Sinohydro Corporation Ltd.
(2018 Aug -Till date):

- Coordination for preparation of sub-drawing.
- Technical report writing and preparation of method statement for different technical activities.
- Coordinator of grouting.
- Preparation of project schedule.
- Involvement in Other activities which belongs to technical department etc.

Curriculum Vitae

Name: Suraj Giri

Email: Surajgiree07@gmail.com

Phone: 9842206438

Address: Gyaneshwor, Kathmandu

ACADEMIC BACKGROUND

SN	Exam passed	Institution	Year	Core Subject
1	Master in Science (M.Sc.)	Tribhuvan University	2018 A.D	Hydrogeology
2	Bachelor in Science (B.Sc.)	Tribhuvan University	2071 B.S	Geology

OTHER SKILLS & EXPERIENCES

IT-Skills:

- Arc Gis, Rockwork, and AutoCAD.

Language: Nepali, English & Hindi.

Work-Experiences:

- Worked in *the program:* "Local Technique Method for Landslide Control", organized by NAST.
- Worked as Geologist in the WWF (Hariyo Ban) project organized by IOF college: "Spring Inventory in The Watershed of Nine Lake of Pokhara- Lekhnath Area."
- Worked as Geologist in Asha Project: "Spring Inventory in the Aawalparajul-03, Dailekh".
- Worked as Geologist: "Spring Inventory in the Southern Part of Kathmandu Valley".

Current-Work:

- As Geologist in:
  -Sinohydro Corporation Ltd., Lamabagar, Dolakha.
  (Upper-Tamakoshi Hydroelectric Project Ltd.)
- Major Responsibilities:
  -Geological Mapping.
  -Grouting (Barrier, Contact, Backfill & Chemical).
  -Knocking test, Thickness test, Rock-bolt pulling test, Rockmass Classification.
  -Core Logging.
  -Preparing Technical reports, Method Statements.
  -And other geological/engineering fieldworks etc.

Resume of Zhang Zhiping

Personal Information

☆ Native Place: Huai'an, jisngsu province
☆ Date of birth : 1964.4
☆ Major: Industrial and civil Construction
☆School of graduation : Jiangsu radio and television university
☆ Phone : 13511517531 ☆ E-mail: 1129664982@qq.com

Ability and specialty

Professional abilities : ◇Proficient in civil engineering construction and management, project summary, Construction line measurement, foundation treatment, construction engineering bidding etc.

Comprehensive abilities : ◇Strong sense of responsibility, independent working ability, hard-working, good team spirit.
◇Good planning, organization, coordination and management abilities.

Education Experience

1984.9-1987.7 Jiangsu radio and television university Mjor: Industrial and civil Construction

1981.9-1984.7 Huai'an zhuqiao middle school High school

Main Resume:

●1987.8-1901.4 Construction budget clerk of Zhenjiang, Jiangsu Province.
●1901.4-1998.5 Construction and management of five construction companies in Huaian, Jiangsu Province.
●1998.6-2000.3 Mainly responsible for the construction and management of large Foundation Pit pile Foundation in Hebei Dadi Group.
●2000.4-2004.7 Responsible for engineering construction and management in Shanghai Rongsheng Foundation Treatment Company , the main project are Shanghai Taipuhe pumping station all pile Foundation and grouting as well asYunnan South Power station diversion tunnel grouting.
●2004.10-2011.9 Jiangsu Nantong Four construction engineer, the main projects :

Shanghai Crown Apartments 3 (18 floors) by the Magnolia Award; Shanghai Huaqiao Apartment 4 (33 floors) won the Project Quality Award.

●2011. 12-2018. 6 Responsible for management among the 11th Bureau of Hydropower station, the dam is a permanent high-pressure rotary spraying pile, the dam cofferdam grouting, water Diversion tunnel grouting, Curicani Power station project Powerhouse Foundation grouting, diversion tunnel grouting, water Seven Bureau La Souvat power station to do the standard test, Jinzhong to Taiyuan Intercity railway 2# as well as the project construction and management of the line in Jinzhong section of rotary digging pile bearing platform.

Shift Site Engineers

1. Name : Prabin B.K.
   Address : Dolakha Nepal
   Phone Number : 9844427896
   Post : Site Engineer
   Education : Diploma in Civil Engineering
   Work Experience : 2 Year in Sinohydro Corporation Pvt. Ltd.
   (Site Engineer in HRT, having grouting experience in dam site of UTKHEP)

2. Name : Madan Khadka
   Address : Dolakha Nepal
   Phone Number : 9860375343
   Post : Site Engineer
   Education : Diploma in Civil Engineering
   Work Experience : 2 Year in Sinohydro Corporation Pvt. Ltd.
   (Site Engineer in HRT, having grouting experience in dam site of UTKHEP)

3. Name : Krishna Bahadur Hayu
   Address : Sindhuli, Nepal
   Phone Number : 9844206403
   Post : Site Engineer
   Education : Diploma in Civil Engineering
   Work Experience : 2 Year in Sinohydro Corporation Pvt. Ltd.
   (Site Engineer in HRT, having grouting experience in dam site of UTKHEP)

Grouting Operators

1. Name : Yam Prasad Parajuli
   Work Experience : 3 year in Sinohydro Corporation Pvt. Ltd.
   (Including grouting operator in UTKHEP dam Site)

2. Name : Santa Ram Chaudhary
   Work Experience : 5 year in Sinohydro Corporation Pvt. Ltd.
   (Including grouting operator in UTKHEP dam Site)

3. Name : Zui Ji Huai
   Work Experience : 3 year in Sinohydro Corporation Pvt. Ltd.
   (Including grouting operator in UTKHEP dam Site)

4. Name : Liu yong Ming
   Work Experience : 3 year in Sinohydro Corporation Pvt. Ltd.
   (Including grouting operator in UTKHEP dam Site)

According to condition, further skilled manpower will be managed. Shift site engineers are responsible for the submission of the daily records (activities) which include: grouting records, permeability records, summary of works. All these information will be reported using the approved forms.

Safety Plan

Simple Risk Ranking Matrix (For estimating relative risk and ranking numerically)				
	Severity of harm			
Likelihood of harm		Minor(1)	Medium(2)	High(3)
	Low(1)	1	2	3
	Med(2)	2	4	6
	High(3)	3	6	9

Quantitative:

The severity of harm: 3-Major(Death, Major illness causing long term disability); 2-Serious(illness or injuries causing short term disablity); 1-Slight.

The likelihood of harm: 3-High(Certain/near certain that harm will occur); 2-Medium(Where harm will often occur); 1-Low(where harm will seldom occur).

Management of health and safety work regulations risk assessment to Barrier Grouting of Headrace Tunnel

Assessment reference no	101	Description of task to be carried out
Name of assessor	Guo Leimei	The following risk assessment looks at the hazards and controls involved with the barrier grouting of Headrace Tunnel. The risk assessment will be carried out on the construction site during the barrier grouting. Please use this risk assessment as a guide only, all the staff should be resposible for safety and risk assessment. In Barrier grouting (at HT4 and HT3), injection of cement grout with high pressure is done into the holes in tunnel. Maximum risk are considered related to barrier grouting in this risk assessment. Risk and risk afeter risk assessment are expressed in risk ranking matrix form which will help us to prioritize the risk in barrier grouting work. Following are the risk and their assessment.
Other perssons involved in risk assessment	Shadananda Gautam, Chyenga Gyaltsen	
Date of assessment	12 May, 2019	
Managers authorisation	Sheng Dong Feng	
Review date	13 May, 2019	

		Without Safety controls				Considering Safety Control				
what are the hazards?	who might be harmed	likelihood	severrity	risk rating	what controls are in place?	likelihood	severrity	risk rating	what additional controls are required?	process steps involved?
Poor visibility	All the participants in barrier grouting work	2	2	4	1.All participants need to wear the reflective vest before they enter into the Headrace Tunnel to start the barrier groutting work; 2.stick the reflective tip to the barrier grouting's equipment: drilling machine, grouting pump, colloidal mixture, cable etc. 3.provide sufficient lighting in the working area.	1	1	1	No additional control are required.	
Noise (over 85 dBA) and vidration from drilling	The drillers and other workers invloved in barrier grouting.	3	2	6	1.All participants need to wear the earplugs and safety protective gloves before starting drilling work; 2. Working hour of each person should be reduced. One person one shift in a day.	2	1	2	No additional control are required.	
Mishanding of drilling rod and machinery	All the participants in barrier grouting work	1	3	3	1.Before starting work, grouting leader collaborating with safety officer will give safety instruction for proper use of machines. 2.All manpower will do their specific job. He should be well known about use of equipments. 3.before use of drilling rod and machinery, the site engineer should carry safety inspection collaborating with safety officer.	1	3	3	the site Engineer and grouting leader will supervise drilling work or use of machinery on site.	

Dust generation	All the participants in barrier grouting work	2	2	4	1.Mask will be compulsory for all manpower. 2. Proper ventilation will be fascilated.	2	1	2	No additionalcontrol are required.	
Toxic gas (CO,CO2,etc .) release	All the participants in barrier grouting work	2	1	2	1.Proper ventillation will be facillated. 2.The safety officer should check wheather the all the manpower use mask or not. 3. In case of finding symtom of release of toxic gas, all the manpower should take out of tunnel.	1	1	1	No additional control are required.	
Overturning of plant or equipment	Operator and other labor	1	3	3	1. Grouting leader will check the stability of the grouting platform and other equipment. 2.Safety officer should remind the grouting leader about stability of the plateform and other equipment.	1	1	1	No additionalcontrol are required.	
Grout, cement or dust in eyes	Groutig leader, operator and other labor	1	3	3	1. Safety goggles should be provided to operator and other labor during grouting. 2. The workers should follow the safety management rules and wear the protective goggles and mask properly. 3.The safety officer should check the protective goggles and mask wear properly in the daily Tool Box Meeting.	1	2	2	No additional control are required.	

Strike by high pressure air or grout	Grouting leader, Operator and other labor	2	3	6	1.Grouting leader should control site .i.e he should be responsible for safety education for this. 2. Operator should regulate pressure carefully. 3. During grouting, operator and other labor should not be near to the grouting pipe. It may burst during grouting.	1	3	3	No additional control are required.	
Grout spraying out from the steel pipe	Grouting leader and labors	1	2	2	1. Connector should be tightened properly. 2. After completion of grouting, valve in steel pipe should be closed first, then grouting pipe should be removed. Packer should be tightened properly.	1	1	1	No additional control are required.	
Burns & irritation from contact with grout or cement	Grouitng leader, operator and labor	1	2	2	1.The safety officer should check the workers wheather they wear protective gloves, goggles, and mask properly or not. 2.Testing of grout should be done 30m away from grouting location. 3. Those people who have allergy with grout should be shifted to other site than grouting site.	1	1	1	No additional control are required.	
Packer blown out of the hole	Grouting leader and other labor	2	3	6	1. Packer should be tightened. 2. Scratched packer should not be used. 3. Diffence in diamter between hole and packer should be small (1 to 2 mm). 4. Pressure resiting capacity of packer should be high.	1	3	3	No additional control are required.	

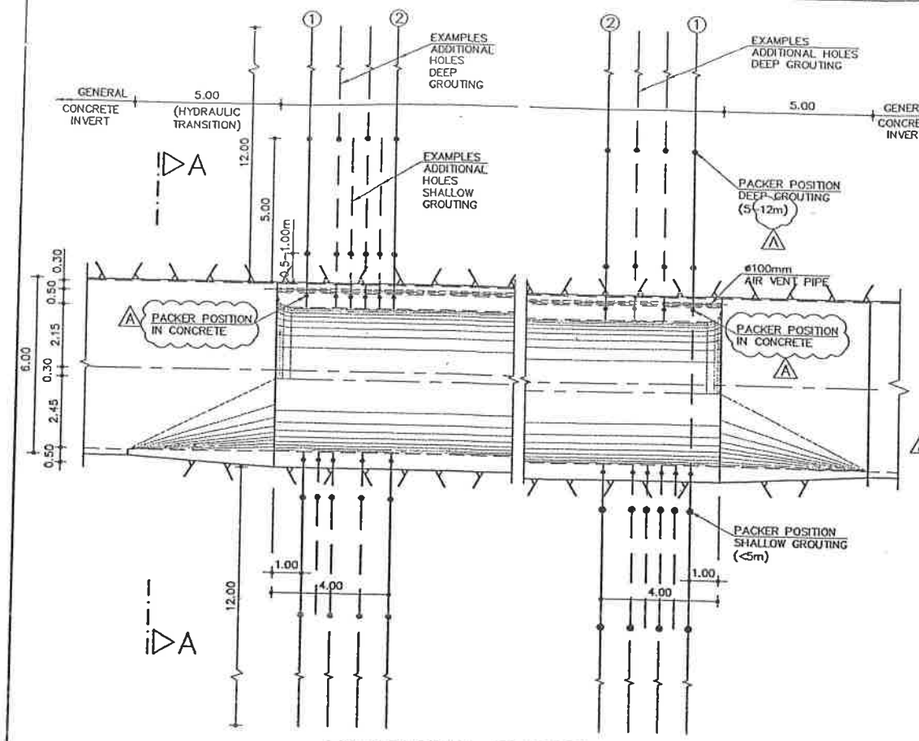
Uncontrolled hoses	Grouting leader, operator and other labor	1	3	3	1.Grouting hoses should be tighten. 2. Connector for grouting hoses should be used properly. 3. Valve connected to hoses should be closed after tighening packer.	1	3	3	No additional control are required.	
Blasting of hoses	Grouting leader, operator and other labor	1	3	3	1.Pressure resisting capacity of grouting hoses should be high. 2. Connection of hoses should be tight.	1	3	3	No additional control are required.	
Slips, trips and falls	All the manpower involved in grouting.	1	3	3	1.Keep the working site clean and tidy. 2. All the manpwoer should wear safety shoes. 3.Keep the eqquipment tidy and orderly.	1	2	2	No additional control are required.	
Falling objects	All the manpwoer involved in barrier grouting.	1	3	3	1. Use of safety helmet should be compulsory. 2. Before starting barrier grouting, safety inspection should be conducted for falling objects.	1	2	2	No additional control are required.	
Working at height	Labors	2	3	6	1. Use of safety belt should be compulsory above 1m height. 2. Stability of groutng platfom should be checked and it should be safe.	1	2	2	No additional control are required.	

Collision during vehicle or equipment movement	the drivers and the workers	1	3	3	1. Visibiliyt should be good. 2. Lightening system should be in good condition. 3.Keep the safety distance to vehicles and equipment.	1	3	3	No additional control are required.	
Entanglement with rotating or moving machinery	The operator who operate the equipments and others workers	2	3	6	1. Grouting leader should check for safety of rotating or moving machinery. 2. Grouting leader should give the safety education to operators how to operate rotating or moving machine safely. 3. gloves should not be used during operation of rotating/moving machine.	1	3	3	No additional control are required.	
Injury due to manual load handing and body posture	All the workers	2	3	6	1. If any manpower is phyically or mentally unfit, then he will not be at site. 2. Workers will not be forced to work beyound his ability. 3.On-site, safety officers should strengthen supervision over violations of regulations of safety rule.	1	2	2	No additional control are required.	
Hazards of fuel storage, handing and refilling	All the workers	1	3	3	1. Grouting leader should manage one foreman who can handle the fuel storage. 2. The safety officer should check the workers wheather they use properly gloves, mask and goggles before they start to work relating fuel storage, handing and refilling. 3. The safety officer should check wheather there is any fire, smoking, or flammable materials in site or not.	1	3	3	No additional control are required.	

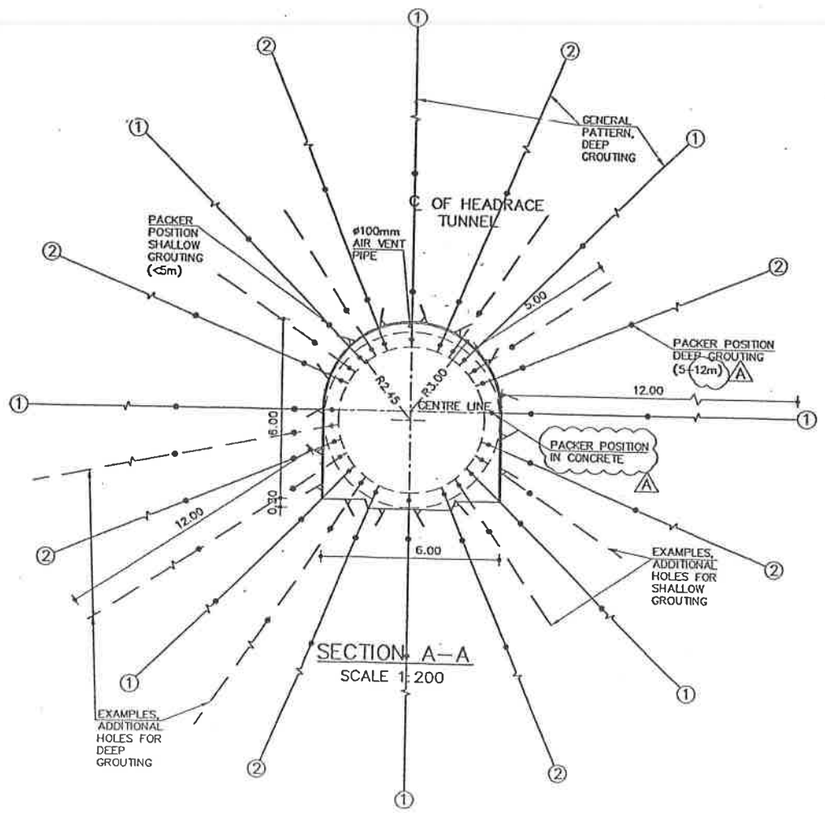
Catching fire	All the wokers	1	3	3	1.Grouting leader should manage sufficient fire extingishers or fire-fighting sand in site; 2. The safety officer give the education to workers about how to use fire extingishers in case of catching fire. 3. Safety education should be provided so that short circuit, smoking will be avoided in sensative location.	1	1	1	No additional control are required.	
Short circuit and electrocution	All the workers and electrician	2	3	6	1.During working period, electrician should use insulated gloves. 2.Only the electrician can repair or maintain the electricity issues and connect the cable to equipments. 3. The electrician should make sure all the electric equipment must be grounded reliably. 4. Safety education about how to give first aid to person who has electric shock should be given to the workers.	1	2	2	No additional control are required.	

YOUR
LOGO
HERE

Design Drawing



LONGITUDINAL SECTION
SCALE 1:200



SECTION A–A
SCALE 1:200

PARTICULAR NOTES

GROUTING BARRIER

1. ALL DESCRIPTIONS BELOW MAY BE MODIFIED BY THE ENGINEER PRIOR TO OR DURING THE COURSE OF THE WORK
2. THE CONTRACTOR SHALL DELIVER A DETAILED PROCEDURE FOR GROUTING WORKS MINIMUM 8 WEEKS BEFORE START OF SUCH WORKS, SEE TECHNICAL SPECIFICATIONS

PREPARATION ALONG ENTIRE LENGTH OF LINING BEFORE PLACING REINFORCEMENT

- THE ROCK SURFACE ALONG THE ENTIRE LENGTH OF THE LINING SHALL BE VERIFIED TO PROVIDE REQUIRED SPACE FOR AN OUTSIDE DIAMETETR OF THE LINING OF 5.9 m
- AREAS WITH UNDERBREAK RELATED TO THE OUTER 5.9 m LINING DIAMETER, OR AREAS TOO NARROW FOR OTHER REASONS, SHALL BE ENLARGED BY CHISELING OR BLASTING TO SATISFY THE REQUIREMENTS
- PIPES FOR BACKFILL GROUTING SHALL BE INSTALLED TO ALL HIGH POINTS UNDER THE CEILING. THE PIPES SHALL TO THE EXTENT POSSIBLE BE INSTALLED BEFORE PLACING THE REINFORCEMENT

PREPARATION OF ROCK SURFACE AT END SECTIONS

- THE ROCK SURFACES AT THE FIRST 5m SECTIONS IN EACH END SHALL BE PREPARED BY REMOVING ALL SHOTCRETE AND STEEL RIBS (IF ANY), THE INVERT SHALL BE CLEANED FOR ALL LOOSE MATERIAL AND THE ROCK CONTOUR AROUND THE WHOLE PERIMETER SHALL BE CHISEL SCALED AND THOROUGHLY CLEANED BY HIGH PRESSURE WATER FLUSHING.
- THESE 5M SECTIONS SHALL NOT BE PROVIDED BY A 1ST STAGE LEAN CONCRETE INVERT

DEEP GROUTING

1. INITIALLY, 12m LONG HOLES SHALL BE DRILLED INTO ROCK IN A RADIAL PATTERN IN TWO FANS: FAN 1 AND FAN 2 AS SHOWN ON THE DRAWING. EACH FAN SHALL HAVE EIGHT HOLES SPACED AT 45° AROUND THE CIRCUMFERENCE. THE HOLES IN FAN 2 SHALL BE DRILLED IN STAGGERED POSITION COMPARED TO THE HOLES IN FAN 1.
2. EACH HOLE SHALL BE WATER PRESSURE TESTED FOR LEAKAGE (LUGEON) WITH PACKER SETTING 5m INSIDE THE ROCK SURFACE
3. AFTER TESTING, ALL HOLES SHALL BE GROUTED WITH PACKER SETTING AT 5m USING CEMENT BASED GROUT TYPE A IF PERMEABILITY IS > 2.0 LUGEON OR TYPE B AT LOWER PERMEABILITY
4. AFTER COMPLETING GROUTING OF FAN 1 AND FAN 2, AND IF PERMEABILITY TESTS IN ANY HOLES HAVE SHOWN WATER LOSS > 0.5 LUGEON, 12 m LONG HOLES SHALL BE DRILLED ON EACH SIDE BETWEEN IN FAN 1 AND FAN 2 IN A "SPLIT SPACING" PATTERN, TESTED AND GROUTED. IF PERMEABILITY IN ANY NEW HOLE HAVE SHOWN WATER LOSS > 0.5 LUGEON NEW 12 m LONG HOLES SHALL BE DRILLED ON EACH SIDE AND TESTED AND GROUTED. THE PROCEDURE WITH ADDING, TESTING AND HOLES SHALL BE REPEATED UNTIL ALL NEW HOLES SHOW WATER LOSS ≤ 0.5 LUGEON. FINAL GROUTING PRESSURE SHALL BE 30 BAR WITH ZERO FLOW FOR 5 MINUTES OR AS DECIDED BY THE ENGINEER DURING THE WORK

SHALLOW GROUTING

5. AFTER COMPLETING DEEP GROUTING, THE OUTER 4 – 4.5 m IN ROCK OF EVERY HOLE SHALL BE WATER PRESSURE TESTED FOR LEAKAGE (LUGEON) WITH PACKER SETTING 0.5 – 1.0 m INTO ROCK
6. AFTER TESTING, ALL HOLES SHALL BE GROUTED (AS DESCRIBED UNDER 4 ABOVE) WITH PACKER SETTING 0.5 – 1.0 M INTO ROCK
7. IF THE WATER PRESSURE TESTS IN ANY HOLE (5 ABOVE) HAVE SHOWN WATER LOSS > 0.5 LUGEON, NEW 5m LONG HOLES SHALL BE DRILLED AT BOTH SIDES OF THE HOLES IN QUESTION, LEAKAGE TESTED AND GROUTED. THIS PROCEDURE SHALL BE REPEATED AS DESCRIBED UNDER 4 UNTIL ALL NEW HOLES SHOW WATER LEAKAGE ≤ 0.5 LUGEON

CONTACT GROUTING

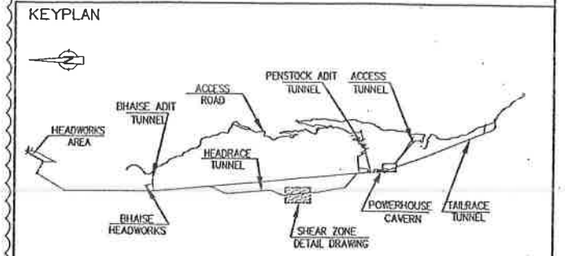
8. AFTER COMPLETING SHALLOW GROUTING ALL HOLES ARE THROUGHLY FLUSHED
9. WITH PACKERS PLACED IN THE CONCRETE, THE HOLES ARE WATER LOSS TESTED (LUGEON) AT A PRESSURE OF 10 BAR. IN ORDER TO PREVENT LEAKAGE INTO THE TUNNEL, THE CIRCUMFERENTIAL JOINT BETWEEN CONCRETE AND ROCK AT THE END OF THE LINING SECTION OF THE HOLES, SHALL BE SEALED BY EXPANDING MORTAR
10. AFTER TESTING, ALL HOLES SHALL BE GROUTED WITH PACKERS PLACED IN THE CONCRETE USING CEMENT BASED GROUT TYPE A IF PERMEABILITY > 2.0 LUGEON OR TYPE B AT LOWER PERMEABILITY IF PERMEABILITY TESTS IN ANY HOLE HAVE SHOWN WATER LOSS > 0.5 LUGEON, NEW HOLES SHALL BE DRILLED 2 m INTO THE ROCK ON BOTH SIDES OF THE HOLES IN QUESTION, TESTED, GROUTED AND RETESTED. THE PROCEDURE WITH ADDING, TESTING AND HOLES SHALL BE REPEATED UNTIL ALL NEW HOLES SHOW WATER LOSS ≤ 0.5 LUGEON. FINAL GROUTING PRESSURE SHALL BE 30 BAR WITH ZERO FLOW FOR 5 MINUTES OR AS DECIDED BY THE ENGINEER DURING THE WORK
11. AFTER COMPLETED GROUTING ALL HOLE COLLARS SHALL BE SEALED BY EXPANDING MORTAR.

NOTES:

1. DRAWING IS VALID FOR CONCRETE LININGS:
   CHAINAGE 3+557 TO 3+727
   CHAINAGE 3+795 TO 3+830
   CHAINAGE 4+395 TO 4+505
   CHAINAGE 6+051 TO 6+131
2. ALL DIMENSIONS ARE IN METERS(m) UNLESS OTHERWISE NOTED.
3. AT EACH END OF THE SHEAR ZONES THE REINFORCED LINING SHALL OVERLAP 5.0m INTO SOLID ROCK.
4. THE CONTRACTOR HAS TO INSTALL HIS OWN AIR EVACUATION PIPES TO AVOID VOIDS UNDER THE CEILING WHEN CONCRETING
5. IN ORDER TO REDUCE THE INCONVENIENCE OF DRILLING THROUGH REINFORCEMENT THE INITIAL DRILL PATTERN MAY BE SET OUT BY TRACEABLE EMBEDDED PLASTIC PIPES.

SCALE 1:200
−4 0 4 8 12 16 20 [m]

KEYPLAN



ISSUED FOR CONSTRUCTION

Reference Drawings

Drwg. No.	Title

Revisions					
A	Sverre		10.10.018	REVISED AS SHOWN.	
	Name	Sign.	Date	Notes	

UPPER TAMAKOSHI HYDROPOWER LIMITED
Kathmandu,Nepal
UTKHPL

JV Norconsult AS -
LAHMEYER INTERNATIONAL GmbH

UPPER TAMAKOSHI HYDROELECTRIC PROJECT

FILE CODE

	Name	Sign.	Date
Prepared	A.Bataju		May 018
Drawn	R.K.S.		May 018
Checked	Sverre		May 018
Approved	William		May 018

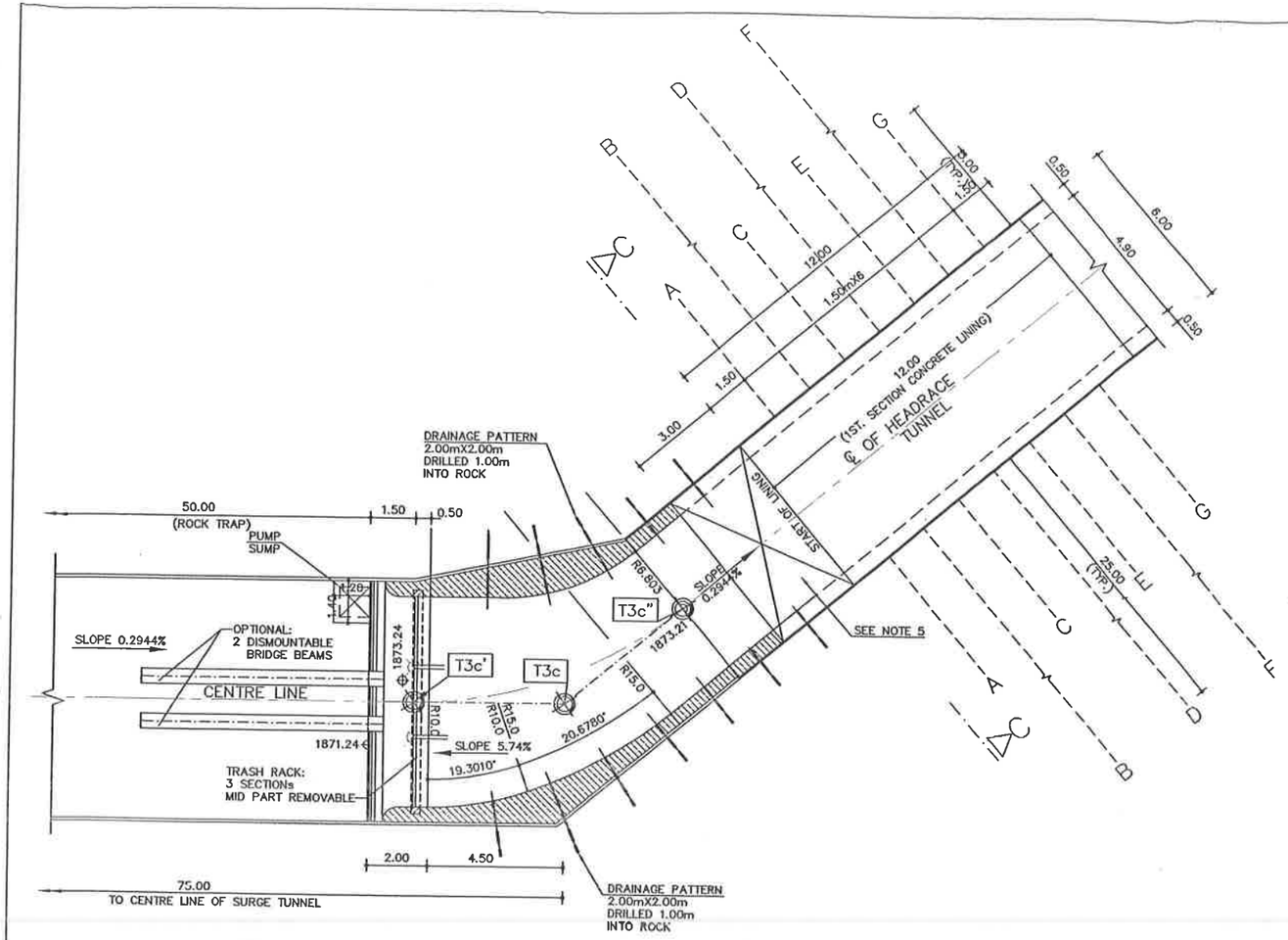
Supersedes

CAD–File No.:

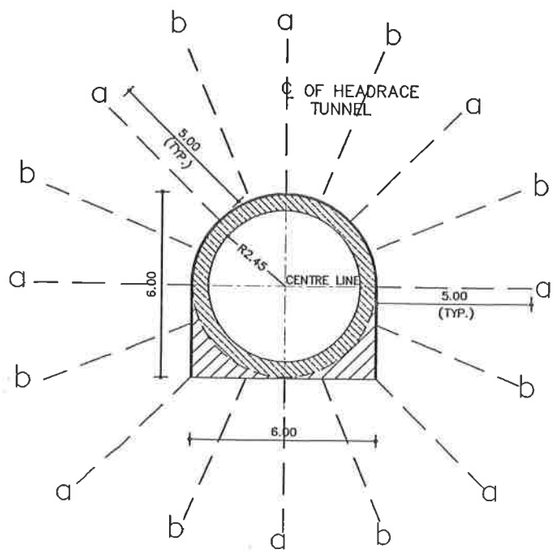
FINAL DESIGN

HRT & BHAISE ADIT
HEADRACE TUNNEL

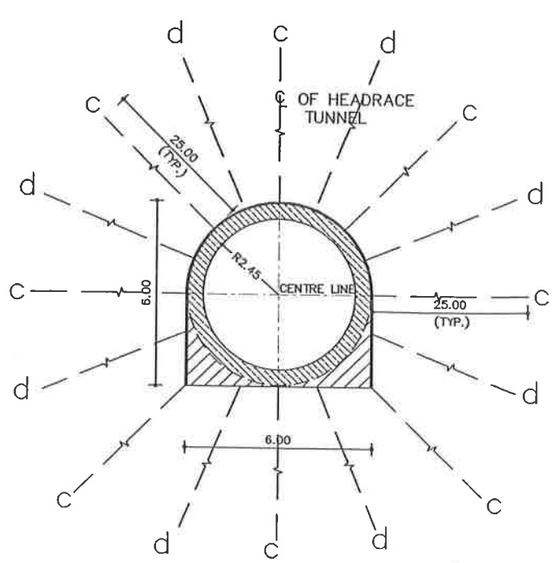
SHEAR ZONE LININGS
GROUTING BARRIER
GROUTING DRAWING



PLAN
SCALE 1:200



SECTION SHALLOW GROUTING
Position a: FAN A & E
Position b: FAN C & G
SCALE 1:200



SECTION DEEP GROUTING
Position c: FAN B & F
Position d: FAN D
SCALE 1:200

PARTICULAR NOTES:

1. PREGROUTING PRIOR TO CASTING OF CONCRETE LINING ALL PROCEDURES BELOW MAY BE MODIFIED BY THE ENGINEER. THE CONTRACTOR SHALL DELIVER DETAILED PROCEDURES FOR THE WORK MINIMUM 6 WEEKS PRIOR TO START OF GROUTING WORKS, SEE TECHNICAL SPECIFICATION.

1.1 SHALLOW GROUTING 5m LONG HOLES IN ROCK
HOLES SHALL BE DRILLED IN A RADIAL PATTERN IN FOUR GROUT FANS; A, C, E AND G. EACH FAN CONSISTING OF EIGHT HOLES SPACED AT 45° AROUND THE CIRCUMFERENCE. HOLES IN FAN C AND G SHALL BE DRILLED IN STAGGERED POSITION COMPARED TO FAN A AND E.
PERFORM WATER PRESSURE TESTING WITH PACKER SETTING AT 0.5m FROM ROCK SURFACE. AFTER TESTING, THE HOLES SHALL BE GROUTED WITH CEMENT BASED GROUT TYPE A IF PERMEABILITY IS LARGER THAN 2 LUGEON AND TYPE B WITH LOWER PERMEABILITY. FINAL GROUTING PRESSURE SHALL BE AT 30 BAR FOR MINIMUM 5 MINUTES OR AS DIRECTED BY THE ENGINEER DURING GROUTING. PACKER SETTING AT 0.5–1.0m DEPTH AS DIRECTED BY THE ENGINEER. IF THE WATER PRESSURE TEST IN ANY GROUTING HOLE SHOWS WATER LOSS ABOVE 0.5 LUGEON, NEW HOLES SHALL BE DRILLED AT BOTH SIDES AT A "SPLIT SPACING" PATTERN IN EACH FAN, TESTED AND GROUTED. THIS PROCEDURE SHALL BE REPEATED UNTIL ALL HOLES IN EACH FAN SHOW WATER LOSSES BELOW OR EQUAL TO 0.5 LUGEON.

1.2 DEEP GROUTING 25m LONG HOLES
HOLES SHALL BE DRILLED IN A RADIAL PATTERN IN THREE GROUT FANS; B, D AND F. EACH FAN CONSISTING OF EIGHT HOLES SPACED AT 45° AROUND THE CIRCUMFERENCE. HOLES IN FAN D SHALL BE DRILLED IN STAGGERED POSITION COMPARED TO FAN A AND E.
PERFORM WATER PRESSURE TESTING WITH PACKER SETTING AT 2m FROM ROCK SURFACE. AFTER TESTING, THE HOLES SHALL BE GROUTED WITH CEMENT BASED GROUT TYPE A IF PERMEABILITY IS LARGER THAN 2 LUGEON AND TYPE B WITH LOWER PERMEABILITY. FINAL GROUTING PRESSURE SHALL BE AT 45 BAR FOR MINIMUM 5 MINUTES OR AS DIRECTED BY THE ENGINEER DURING GROUTING. PACKER SETTING AT 0.5–1.0m DEPTH AS DIRECTED BY THE ENGINEER. IF THE WATER PRESSURE TEST IN ANY GROUTING HOLE SHOWS WATER LOSS ABOVE 0.5 LUGEON, NEW HOLES SHALL BE DRILLED AT BOTH SIDES AT A "SPLIT SPACING" PATTERN IN EACH FAN, TESTED AND GROUTED. THIS PROCEDURE SHALL BE REPEATED UNTIL ALL HOLES IN EACH FAN SHOW WATER LOSSES BELOW OR EQUAL TO 0.5 LUGEON.
UPON COMPLETION OF GROUTING ALL BOREHOLE COLLARS SHALL BE FILLED UP BY EXPANDING MORTAR.

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS [m] UNLESS OTHERWISE NOTED.
2. ALL ELEVATIONS ARE IN [masl].
3. EXCAVATION LINE FOR TRANSITION AND ROCK TRAP SECTION AS MARKED ON DRAWING HAS TO BE ENLARGED ACCORDING TO THE DIMENSIONS OF ROCK SUPPORT MEASURED e.g. SHOTCRETE/STEEL RIB SUPPORT THICKNESS.
4. FINAL EXCAVATION PROFILE OF HEADRACE TUNNEL BETWEEN T4" AND T3c2 SHALL NOT BE LESS THAN 5.9m, ROCK SUPPORT MEASURES RS4, RS AND PARTIALLY RS3 SHALL BE ARRANGED OUTSIDE OF 5.9m.
5. A 3m LONG SECTION OF THE TRANSITION PART SHALL BE CAST AFTER 1ST. SECTION OF THE CONCRETE LINING AND AFTER POSTGROUTING.
6. PREPARATION OF ROCK SURFACES, SEE DWG. 4420–Q 016 CONTACT GROUTING, SEE DWG. 4420–Q 017 POST GROUTING, SEE DWG. 4420–Q 018

SCALE 1:100
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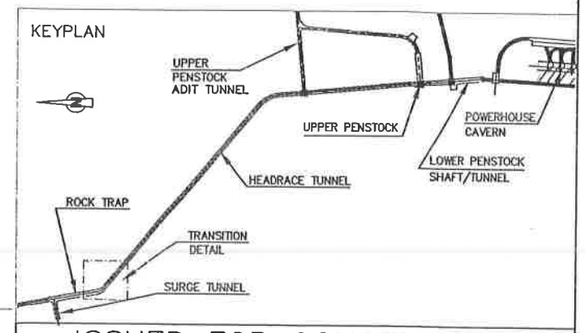
SCALE 1:200
−4 0 4 8 12 16 20 [m]

KEYPLAN



ISSUED FOR CONSTRUCTION

Reference Drawings

Drwg. No.	Title
UTK–012065–4520–S 001	Surge Shaft–HRT to Surge Shaft–Surge Tunnel–Layout...
UTK–012065–4520–S 020	HRT & Bhaise Adit–Rock Trap–Plan and Sections

Revisions				
A	SVERRE		13.01.2018	ADDED NOTE
	Name	Sign.	Date	Notes

UTKHPL
UPPER TAMAKOSHI HYDROPOWER LIMITED
Kathmandu,Nepal

JV Norconsult AS -
LAHMEYER INTERNATIONAL GmbH

UPPER TAMAKOSHI HYDROELECTRIC PROJECT

FILE CODE

	Name	Sign.	Date
Prepared	A.Bataju	—	Jan.018
Drawn	Bishnu	—	Jan.018
Checked	Sverre		Jan.018
Approved	G. Hoelzl		Jan.018

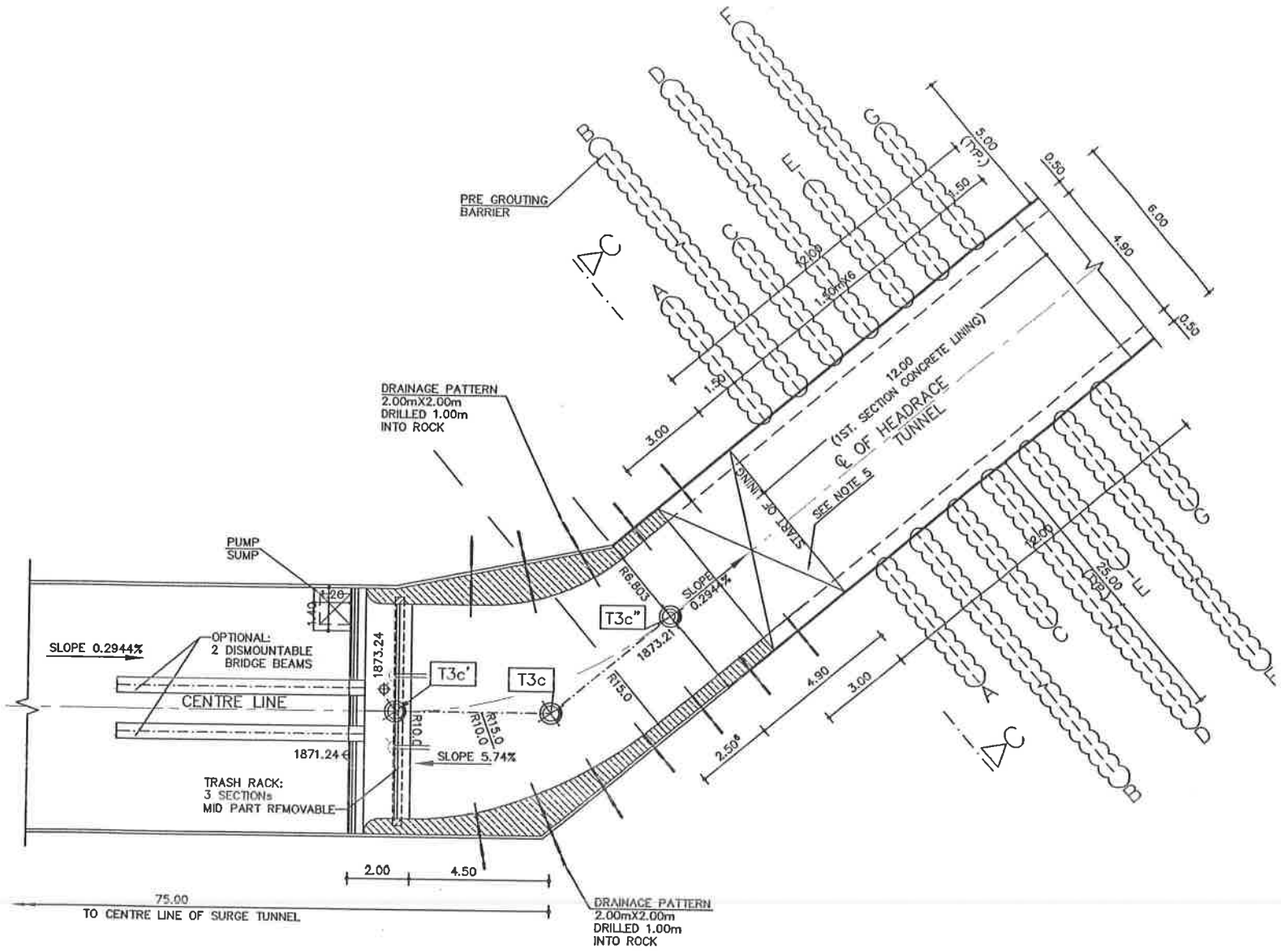
Supersedes

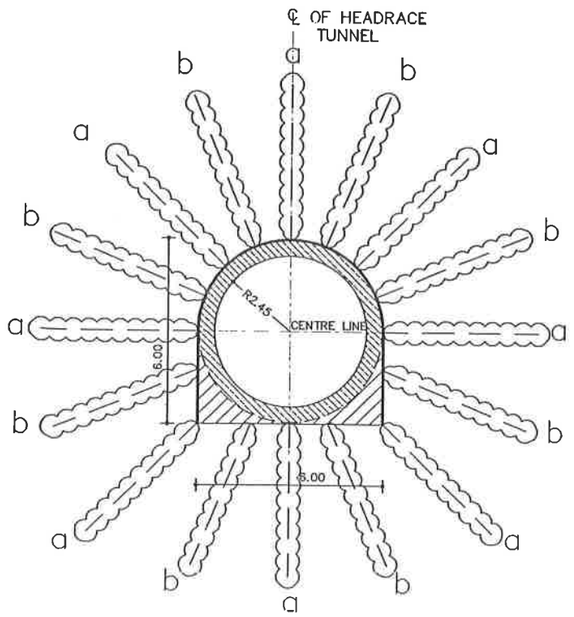
CAD–File No.:

Scale A1: 1:100
Scale A3: 1:200

FINAL DESIGN
HEADRACE TUNNEL
CONCRETE TUNNEL
TRANSITION
PREGROUTING BARRIER
GROUTING DRAWING

Drwg. No.: UTK–012065–4420 Q–015 REV. A





SECTION C–C
SCALE 1:200

PARTICULAR NOTES:

PREPARATION OF ROCK SURFACES FOR UPPERMOST SECTION OF CONCRETE LINING.

- THE 12m LONG UPPERMOST SECTION OF THE CONCRETE LINING IS DESIGNED AS CONCRETE PLUG BETWEEN THE ROCK TRAP AND THE DOWNSTREAM CONCRETE LINED HEADRACE TUNNEL.
- BEFORE PREPARATION FOR THE REINFORCEMENT OF THE FIRST 12m SECTION OF THE CONCRETE LINING, ALL SHOTCRETE AND STEEL RIBS (IF ANY) SHALL BE REMOVED ALONG THE LENGTH OF THE SECTION. THE INVERT SHALL BE CLEANED FOR ALL LOOSE MATERIAL AND THE ROCK CONTOUR AROUND THE WHOLE PERIMETER SHALL BE CHISEL SCALED AND THOROUGHLY CLEANED BY HIGH–PRESSURE WATER–FLUSHING.
- THIS SECTION SHALL NOT BE PROVIDED BY A 1ST. STAGE LEAN CONCRETE INVERT.
- AREAS OF UNDERBREAK, IF ANY SHALL BE ENLARGED BY CHISELLING OR BLASTING TO SATISFY THE THEORETICAL CONTOUR.
- PIPES FOR BACKFILL GROUTING AND FLEXIBLE HOSES AND SUPPLY PIPES FOR CONTACT GROUTING ARE DESCRIBED AND SHOWN ON DWG 4420–Q 017. INSTALLATION OF THESE PIPES SHALL TO THE EXTENT POSSIBLE BE COMPLETED BEFORE START REINFORCEMENT.

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS [m] UNLESS OTHERWISE NOTED.
2. ALL ELEVATIONS ARE IN [masl].
3. EXCAVATION LINE FOR TRANSITION AND ROCK TRAP SECTION AS MARKED ON DRAWING HAS TO BE ENLARGED ACCORDING TO THE DIMENSIONS OF ROCK SUPPORT MEASURED e.g. SHTOCRETE/STEEL RIB SUPPORT THICKNESS.
4. FINAL EXCAVATION PROFILE OF HEADRACE TUNNEL BETWEEN T4" AND T3c2 SHALL NOT BE LESS THAN 5.9m, ROCK SUPPORT MEASURES RS4, RS AND PARTIALLY RS3 SHALL BE ARRANGED OUTSIDE OF 5.9m.
5. A 3m LONG SECTION OF THE TRANSITION PART SHALL BE CAST AFTER 1ST. SECTION OF THE CONCRETE LINING AND AFTER POSTGROUTING.
6. PREGROUTING BARRIER, SEE DWG. 4420–Q 015 CONTACT GROUTING, SEE DWG. 4420–Q 017 POST GROUTING, SEE DWG. 4420–Q 018

SCALE 1:100
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SCALE 1:200
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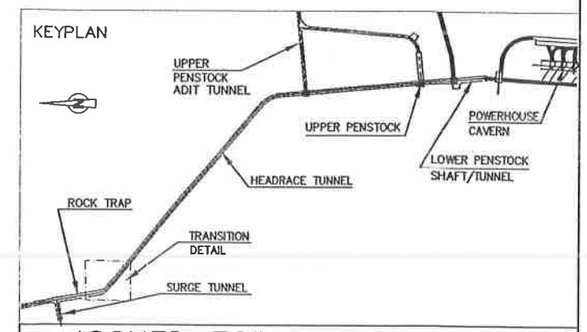
KEYPLAN



ISSUED FOR CONSTRUCTION

Reference Drawings

Drwg. No.	Title
UTK–012065–4520–S 001	Surge Shaft–HRT to Surge Shaft–Surge Tunnel–Layout...
UTK–012065–4520–S 020	HRT & Bhaise Adit–Rock Trap–Plan and Sections

Revisions					
	A	SVERRE		13.01.2018	ADDED NOTES
		Name	Sign.	Date	Notes

UPPER TAMAKOSHI HYDROPOWER LIMITED
Kathmandu,Nepal
UTKHPL

JV Norconsult AS -
LAHMEYER INTERNATIONAL GmbH

UPPER TAMAKOSHI HYDROELECTRIC PROJECT

FILE CODE

	Name	Sign.	Date
Prepared	A.Bataju	—	Jan.018
Drawn	Bishnu	—	Jan.018
Checked	Sverre		Jan.018
Approved	G. Hoelzl		Jan.018

Supersedes

CAD–File No.:

Scale A1: 1:100
Scale A3: 1:200

FINAL DESIGN

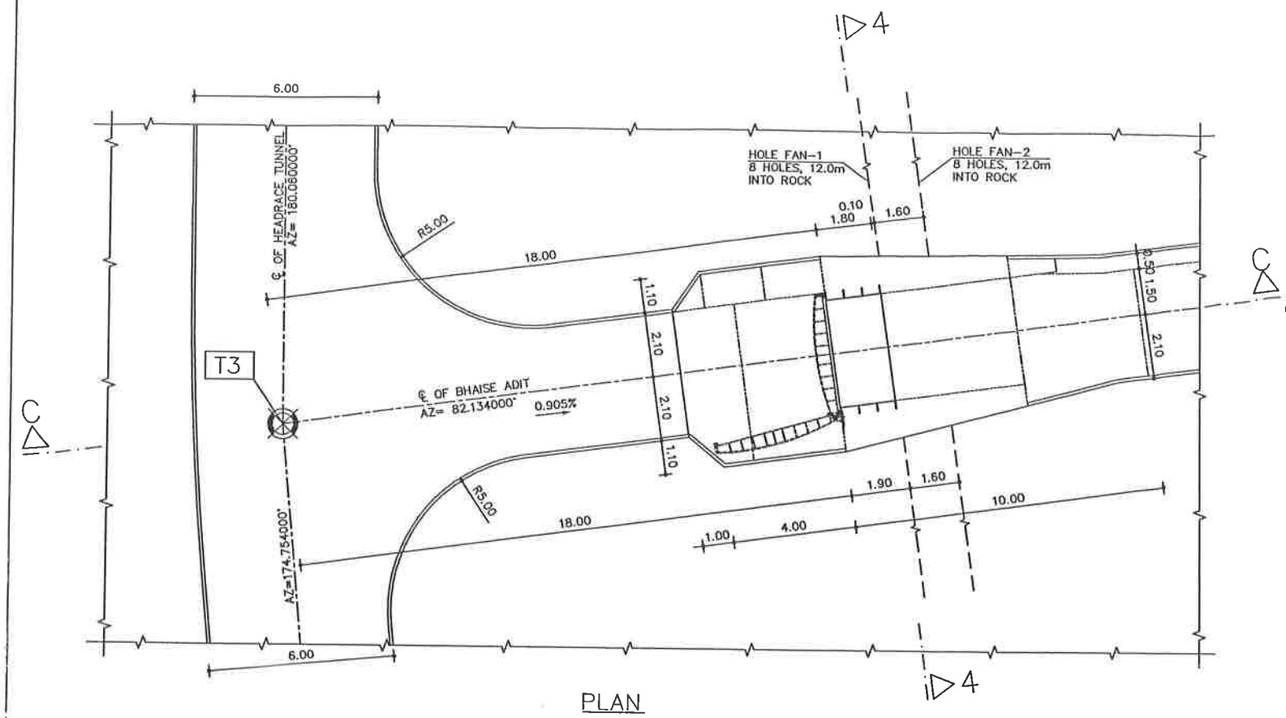
HEADRACE TUNNEL

CONCRETE TUNNEL

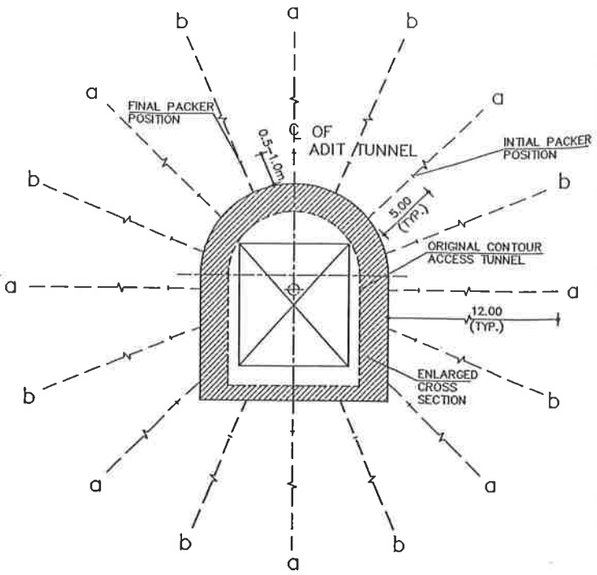
TRANSITION AREA BETWEEN UNLINED AND LINED TUNNEL

PREPARATION ROCK SURFACES

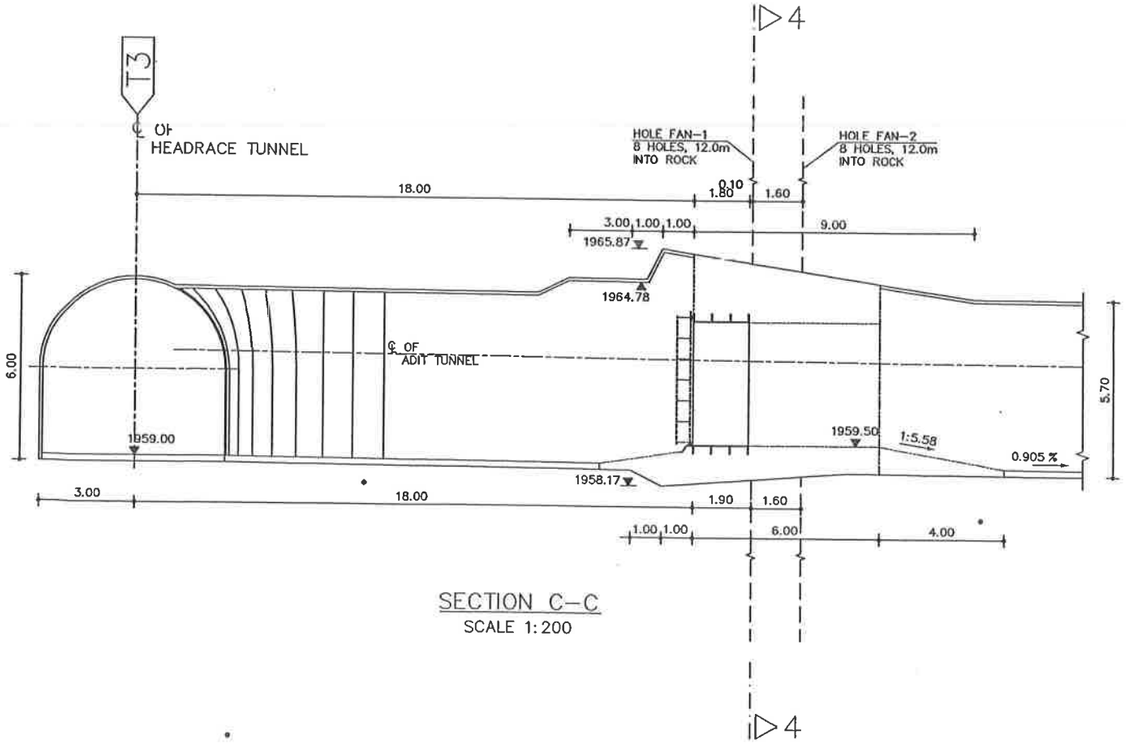
Drwg. No.: UTK–012065–4420 Q–016 REV. A



PLAN
SCALE 1: 200



SECTION 4–4 (A)
(GROUTING BARRIER)
a: FAN–1
b: FAN–2
SCALE 1: 200



SECTION C–C
SCALE 1: 200

PARTICULAR NOTES:

PRE–GROUTING BARRIER:

1. ALL DESCRIPTIONS BELOW MAY BE MODIFIED BY THE ENGINEER PRIOR TO OR DURING THE WORK.
2. THE CONTRACTOR SHALL DELIVER A DETAILED PROCEDURE FOR THE GROUTING WORKS MINIMUM 6 WEEKS BEFORE START OF SUCH WORKS, SEE TECHNICAL SPECIFICATIONS.
3. INITIALLY, 12m LONG HOLES SHALL BE DRILLED IN A RADIAL PATTERN IN TWO FANS: FAN 1 & FAN 2 AS LOCATED ON DRAWING. EACH FAN SHALL HAVE EIGHT HOLES SPACED AT 45° AROUND THE CIRCUMFERENCE. THE HOLES IN FAN 2 SHALL BE DRILLED IN STAGGERED POSITIONS COMPARED TO THE HOLES IN FAN 1.
4. EACH HOLE SHALL BE WATER PRESSURE TESTED FOR LEAKAGE (LUGEON, 10 BAR OVERPRESSURE) WITH PACKER SETTING 5m INSIDE THE ROCK SURFACE.
5. AFTER TESTING THE HOLES SHALL BE GROUTED WITH PACKER SETTING AT 5m USING CEMENT BASED GROUT TYPE A IF PERMEABILITY IS ABOVE 2 LUGEON AND TYPE B AT LOWER PERMEABILITY. FINAL GROUTING PRESSURE SHALL BE 30 BAR WITH ZERO FLOW FOR MINIMUM 5 MINUTES OR AS DECIDED BY THE ENGINEER DURING THE GROUTING WORK.
6. IF THE WATER PRESSURE TEST (REF. 4 ABOVE) IN ANY FAN SHOW WATER LOSS ABOVE 0.5 LUGEON, NEW HOLES SHALL BE DRILLED AT BOTH SIDES OF THE HOLE AT A " SPILT SPACING" PATTERN WITHIN THE FAN. WATER PRESSURE TESTED AND GROUTED AS DESCRIBED ABOVE. THIS PROCEDURE SHALL BE REPEATED UNTIL ALL NEW HOLES IN BOTH FANS SHOW WATER LOSS EQUAL TO OR BELOW 0.5 LUGEON.
7. THEREAFTER EVERY HOLE SHALL BE WATER PRESSURE TESTED (LUGEON, 10 BAR OVERPRESSURE) WITH PACKER SETTING 0.5–1.0m FROM ROCK SURFACE, GROUTED AS DESCRIBED ABOVE WITH PACKER SETTING AT THE SAME LOCATION. FINAL GROUTING PRESSURE SHALL BE AT 15 BAR AND ZERO FLOW FOR MINIMUM 5 MINUTES OR AS DIRECTED BY THE ENGINEER DURING GROUTING.
8. BASE ON THE RESULT OBTAINED, ADDITIONAL HOLES FOR TESTING AND GROUTING MAY BE REQUESTED BY THE ENGINEER DURING THE GROUTING WORK.

NOTES:

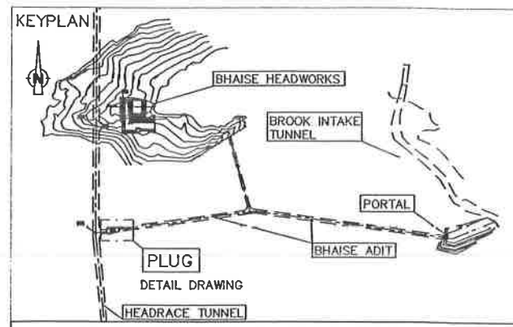
1. SEE COVER SHEET UTK–012065–4140–Q 001.

EXCAVATION:

1. ENLARGEMENT OF CROSS SECTION FOR ACCOMMODATING CONCRETE PLUG SHALL BE PERFORMED BY PERIMETER BLASTING (TECHNICAL SPECIFICATION 6.8.2.)
2. ALL ROCK SURFACE INTERFACING CONCRETE STRUCTURES SHALL BE CHISEL SCALED FOR REMOVING ALL LOOSE AND DRUMMY ROCK.
3. ▨ CROSS SECTION ENLARGEMENT.

SCALE 1:200
–2 0 2 4 6 8 10 [m]

KEYPLAN



ISSUED FOR CONSTRUCTION

Reference Drawings

Drwg. No.	Title
UTK–012065–4410–Q 050	BHAISE ADIT, PLAN AND SECTIONS

Revisions				
B	SVERRE		12.01.2018	REMOVED SHOTCRETE BETWEEN CONCRETE AND ROCK.
A	SVERRE		08.01.2018	ADDED NOTES & CHANGED DIMENSION
	Name	Sign.	Date	Notes

UTKHPL
UPPER TAMAKOSHI HYDROPOWER LIMITED
Kathmandu,Nepal

JV Norconsult AS -
LAHMEYER INTERNATIONAL GmbH

UPPER TAMAKOSHI HYDROELECTRIC PROJECT

FILE CODE

	Name	Sign.	Date
Prepared	A.Bataju	—	Nov.017
Drawn	R.K.S	—	Nov.017
Checked	Sverre		Nov.017
Approved	G. Hoelzl		Jan.018

Supersedes

CAD–File No.:

FINAL DESIGN

BHAISE HEADWORKS

BHAISE ADIT–PLUG

EXCAVATION & GROUTING BARRIER PLAN AND SECTIONS

CONCRETE DRAWING

Scale A1: 1:100
Scale A3: 1:200

Drwg. No.: UTK–012065–4410–Q 060 REV. B